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ATMOSPHERIC CONDITIONS IN THE MIDDLE EAST

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This report describes atmospheric conditions in the Middle East. This area is defined here as Iran, Iraq, the Arabian Peninsula, Syria, Lebanon, Jordan, Israel, and Egypt. A detailed discussion of the extreme variability of precipitation in both space and time is given. Available information about temperature, humidity, fog, dust storms, and solar energy is summarized. Tables of three-hourly seasonal data for Tel Aviv, Jerusalem, Dhahran, Baghdad, and Tehran are included. These tables list means and standard deviations (continued)

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of temperature, dew point, absolute humidity, and wind speed. Maximum and minimum absolute humidities are also included. Visibility and cloud cover are described by frequency distributions.

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I. INTRODUCTION

The term Middle East has several different definitions. In this report, Middle East means the area which includes Egypt, Israel, Jordan, Lebanon, Syria, the Arabian Peninsula, Iraq, and Iran.

The climate of this region is not uniform because the terrain is quite uneven. Coastal plains in the Middle East vary in width from place to place. Much of Iran is a plateau, and a large portion of the Arabian Peninsula is another plateau. Many areas are mountainous. Part of Israel consists of a strip of land below sea level with high mountains on each side.

Precipitation is the element which is most variable in space and time. Mean annual rainfall is adequate in parts of Lebanon, Syria, Iran, and Iraq. Large deserts exist in parts of Iran, the Arabian Peninsula, Syria, and Eqypt. Year-to-year variability of rainfall is high in almost the entire Middle East. It is extremely high in the drier regions where sporadic rains are often heavy enough to cause floods. This report discusses details of spatial and temporal variations of precipitation in the Middle East.

Summers are hot in most of the Middle East, and many areas are also humid. This report contains tables of three-hourly means and standard deviations of temperature, dew point, and absolute humidity at five stations for each season.

Visibility in the Middle East is influenced by dust storms and blowing dust in addition to factors which affect visibility in other parts of the world. Frequency distributions of visibility at five stations are presented for three-hourly intervals during the day in each season.

Latitudinal and seasonal variations of insolation and cloud amount are large in the Middle East. Diurnal changes are also significant at many stations. Three-hourly seasonal frequency distributions of cloud amount at five stations are given in this report.

Finally, means and standard deviations of wind speed at three-hourly intervals for each season are listed for five stations.

II. PRECIPITATION

Arid and semiarid climates prevail in most of the Middle East (Dregne, 1970), and the summer is very dry in almost all of the region. Many stations have no rain at all during the months June through September, and the average rainfall in July is less than 1.0 mm in most of the area. The amount of rainfall in July is negligible even at many locations where the annual mean precipitation is several hundred millimeters.

The driest area is in the interior of Egypt. Luxor (25°40'N, 32°42'E), Dakhla (25°29'N, 29°00'E), and Kharga (25°26'N, 30°34'E) have an annual average of 0 or 1 mm depending upon the period of record (Rudloff, 1981; Environmental Science Services Administration, 1967b). Asswan (23°58'N, 32°47'E) has an annual average of 1 or 2 mm. The mean annual rainfall is less than 40 mm at most stations below 30°N in Egypt (Wernstedt, 1972; Soliman, 1953).

The mean annual rainfall is also less than 40 mm in parts of the Arabian Peninsula and in the desert regions of Jordan and Israel. Eilat (29°33'N, 34°57'E) and the Aqaba Airport (29°33'N, 35°00'E) on the Gulf of Aqaba receive slightly less than 30 mm of precipitation on an annual average (Takahashi and Arakawa, 1981). El-Mudawwara (29°19'N, 35°59'E) is even drier with an annual average of 16 mm (Wernstedt, 1972). The southern part of the Arabian Peninsula is also very dry except for the southwestern plateau. To the north of the plateau, Medina (24°39'N, 39°39'E) and Al Wajh (26°13'N, 36°27'E) receive an average of slightly less than 40 mm of precipitation per year, and Aden (12°50'N, 45°01'E) to the south on the Gulf of Aden receives approximately the same amount (Takahashi and Arakawa, 1981).

Average annual rainfall less than 200 mm is common in the Middle East. These low mean annual values are found in all of Egypt, most of the Arabian Peninsula, and the southern parts of Iran and Iraq. They are also found in eastern and southern Syria, a large part of Jordan, and in the middle and southern parts of the Jordan Valley in Israel.

Some parts of the Middle East receive much more rainfall. The average annual precipitation in most of Lebanon is more than 600 mm, and amounts may reach or exceed 1400 mm in the western hilly district (Takahashi and Arakawa, 1981; Wernstedt, 1972). Even in the drier central and northern parts of the eastern district of Lebanon, the annual average rainfall is expected to be at least 250 mm. In Israel the annual rainfall has an average of 400-800 mm in the coastal district and 600-1000 mm in the hilly district. Mean annual rainfall exceeds 200 mm in the western and northeastern parts of Syria and may exceed 1000 mm in coastal areas. In Jordan both the western hills and eastern hills receive more than 500 mm, and the western hills may have as much as 800 mm annual average precipitation. In the Zagros mountains in the extreme northeastern part of Iraq and northwestern part of Iran average annual precipitation exceeds 1000 mm in some places. The Elburz slopes and the Caspian coast in Iran also have high precipitation. This may be greater than 1500 mm along the western part of the Caspian coast.

The northern part of Iran and the southern part of the Arabian Peninsula are the only locations in the Middle East where the average precipitation in July is more than 1.0 mm. At a few of the Iranian stations several tens of millimeters may fall in the summer, but the largest portion of precipitation falls during the other three seasons. Some stations in the southern part of the Arabian Peninsula actually receive a majority of their precipitation in the summer. For example, Dhala (13°42'N, 44°44'E) at an elevation of 1395 m has an annual average of 376.6 mm, but it receives 105.9 mm in July and 112.7 mm in August. Farther east on the coast of the Arabian Sea, Salalah (17°03'N, 54°06'E) at an elevation of 10 m receives 58.2 mm of its annual 95.9 mm during the three summer months of June, July, and August.

It is a general rule throughout the world that the variability of precipitation is high where average precipitation is low and vice versa. Variability in the Middle East is among the highest in the world. The annual precipitation at Tehran varies between 91 and 560 mm according to Khalili's (1976) study of the years 1894-1974. The range of precipitation during a rainfall year (August through July) at Jerusalem is from 210 mm to 1090 mm during the seasons 1860-61 through 1959-60 according to Striem and Rosenan (1973). In general, a variability is defined as a ratio which is formed when the mean of the absolute values of deviations from the mean is divided by the mean. Maps in Petterssen (1958) and Berry et al. (1973) show that the variability is more than 40 percent in most of the Middle East and is more than 20 percent in almost the entire region. The upper limit of variability in the driest regions is 200 percent (Schumann and Mostert, 1949). Griffiths (1959) cites evidence that most annual variabilities in the world fall within the range of 7 percent to 87 percent. Katsnelson and Kotz (1957) cite a value of 94 percent for Themed in the Sinai peninsula for the rain-years 1921-22 through 1946-47.

Table 1 contains annual precipitations for the years 1951-1960 at a sample of 14 stations with good data in the Middle East. This sample is not located randomly in the region because consistent reliable observations tend to be found in desirable areas where people have chosen to settle. Even in this sample, half of the stations have a variability greater than 30% during the 10-year period, and only Tripoli, Lebanon, has a variability less than 20%. The annual precipitation at Cairo is so changeable that 73 mm fell in 1951 and only 3 mm in 1958. Cairo, Bahrain, Dhahran, and Baghdad all have variabilities greater than 40%. At Tripoli, the 1227 mm for 1953 is more than twice the 609 mm for 1958 even though Tripoli has a variability less than 20%.

Year-to-year variations in the amount of precipitation for a given month in the Middle East are really large. Table 2 contains the amounts of precipitation for January in the years 1951-1960 at the same stations listed in Table 1. The difference between the wettest January and the driest January is at least a factor of four at every station, and the differences are much larger at most stations. At Alexandria, Bahrain, Cairo, and Dhahran the fluctuations are particularly large. For example, the rainfall for both January 1954 and January 1960 is only 1 mm at Bahrain, but the rainfall for January 1959 is 136 mm.

The sporadic rain in the drier parts of the Middle East usually comes in the form of heavy showers which are often accompanied by thunder and lightning. The sporadic nature of rainfall at Baghdad, Iraq, is documented in Normand's (1919) analysis of monthly rainfall for the years 1888-1918. In each month the maximum rainfall in 24 hours during the 31-year period is larger than the mean for that month. Al-Najim's (1975a,c) more recent data for the years 1941-1970 show that the number of thunderstorm days per year in Baghdad varies from 3 to 21, with a mean near 10. This large mean exists even though the average annual precipitation in Baghdad is less than 200 mm. Aqaba Airport in Jordan has an average of 4.1 days with thunderstorms per year even though the average annual precipitation is less than 30 mm (Takahashi and Arakawa, 1981). Soliman's (1953) study of several cases in Egypt based on data up to 1945 contains striking examples of the sporadic nature of precipitation in Egypt. The maximum rainfall for one day is many times the annual mean at several stations, and it is more than the annual mean at 18 of the 30 stations in Soliman's study. Studies of individual weather situations may be found in Ashbel (1938), Durward (1930), Ali (1953), and Dayan and Abramski (1983). Intensities and durations of rainfall at Jerusalem are discussed by Striem and Rosenan (1973).

The heavy sporadic rain the Middle East often causes local flash flooding (Howe et al., 1968), and nearly all desert streams possess a potential for serious floods (Dregne, 1970). Drier regions contain numerous river or stream beds which are only intermittently filled with water. These beds are known as wadis (or sometimes oueds), and they may quite suddenly become torrential rivers of mud, water, and rock. Plant growth often takes place in wadis when the water subsides, and they are sometimes cultivated for agricultural purposes.

Floods may also be caused by drainage of accumulated rainfall or melting snow (Dregne, 1970; Takahashi and Arakawa, 1981). Floods in the great rift in eastern Israel between two mountain ranges are caused by drainage down the slopes on both sides. Floods along larger rivers in the Middle East are usually caused partly by runoff of rain and melting snow from hilly and mountainous regions. The Nile River is subject to annual flooding (Howe et al., 1968). Floods of the Tigris and Euphrates rivers in Iraq are associated primarily with melting of snow on the mountains in the north in spring.

Snowfall in the Middle East is most common in the mountains in the northern and western parts of Iran and in the northeastern part of Iraq (Takahashi and Arakawa, 1981). Tabriz (38°08'N, 46°15'E) at an elevation of 1362 m has a mean of 28.9 days per year with snow. The hilly districts of Lebanon may have 5 to 10 days of snow annually, and the northern part of Syria has an annual average of approximately four days. An annual average of one or two days of snow occurs in Israel and Jordan. Snow need not be considered on the Arabian Peninsula except on very high peaks.

A few studies from the Middle East indicate that there is a diurnal variation in precipitation. Al-Najim (1975c) states that midnight thunderstorms occur frequently in the Arabian Gulf (more commonly called the Persian Gulf). Otterman and Sharon's (1979) investigation of rainfall in the Negev indicates that high-intensity rain has a much higher frequency in the afternoon and early evening than at other hours. Low-intensity rain shows little diurnal

variation. Kutiel and Sharon's (1980) later analysis shows that diurnal variation of rain nearer the coast in Israel is much smaller than in the Negev, and a maximum occurs several hours later. Kutiel and Sharon's (1981) work also reveals that there is a diurnal variation of spatial correlations in the northern Negev. The average correlation between pairs of stations is 0.44 for the period 0600-1200 hours and 0.09 for the six hours from 1200 hours to 1800 hours.

Spatial variations of daily and monthly rainfall totals in Israel are also available. According to Sharon (1979) daily rainfall in the Jordan Valley is largely independent of the rainfall in the surrounding hills in Jordan and Israel. Kutiel's (1982) extensive study of monthly rainfall totals of 22 stations in Israel contains correlations for each station with every other station for 20 rainy seasons. These correlations show that rainfall at Eilat is essentially uncorrelated with rain in most of the rest of the country, and it is not highly correlated with any other station in Israel.

An extensive study of spatial variations of precipitation in and near the Elburz mountain range in northern Iran is discussed by Khalili (1973). Maximum annual mean precipitation of more than 1600 mm is centered at Bandar Pahlavi on the western part of the Caspian coast. There is a secondary maximum of more than 1000 mm near the highest part of the Elburz. An average decrease from north to south of 7 mm/km occurs, and a small mean decrease of 1 mm/km from west to east exists. On the northern slopes of the Elburz, the mean annual precipitation decreases with altitude, and the maximum occurs on the Caspian coastal plain. On the southern slopes, the mean precipitation increases with altitude. The mean correlations between precipitation at pairs of stations in the southern region of the Elburz are 0.53, 0.78, 0.49, and 0.71 in winter, spring, summer, and fall, respectively. Mean correlations between pairs in the northern region are 0.51, 0.55, 0.68, and 0.55 in winter, spring, summer, and fall, respectively. However, precipitation at southern stations is not well correlated with precipitation at northern stations in any season.

On a larger scale, Alexandria, Egypt, and Baghdad, Iraq, have approximately the same mean annual precipitation (Rudloff, 1981), but the correlation of annual precipitation at the two stations based on 66 years of data is only 0.01 (Gabriel and Petrondas, 1984).

A detailed mesoscale study (Khalili, 1976) of the period 1969-1973 in and around Tehran indicates that rural stations average 60 days with measurable precipitation, while urban stations have an annual average of only 43 days. The respective rural and urban numbers become 40 and 35 if only days with a daily total of at least 1.0 mm are considered.

Inadvertent weather modifications due to urbanization in the Middle East may be accompanied by deliberate efforts to modify the atmosphere. Large-scale cloud seeding experiments in Israel on 275 days from 1960 to 1967 are described by Gabriel et al. (1967) and Sharon (1978). The dimensions of rainfall areas increase an average of approximately 10 km on seeded days. However, there is no statistical evidence of persistence of effects of cloud seeding over periods of days or months. Another deliberate modification which has been considered in the Middle East is intentional flooding of land. Segal

et al. (1983) apply a numerical mesoscale model to predict the effects of flooding the Qattara depression in the western desert of Egypt. Their results indicate that the formation of a lake in this region could cause a temperature decrease of a few degrees Celsius and the development of lake breezes during summer afternoons. Such a project is feasible because the Qattara depression is only about 90 km from the Mediterranean shore, and the intervening area has low topographic relief. Surface albedo and temperature can be modified by fencing off an overgrazed area and allowing vegetation recovery. Satellite measurements by Otterman and Tucker (1985) in the northern Sinai during daylight hours in the dry season show that albedo is reduced at least 25 percent and temperatures are actually as much as 2.5°C higher over the vegetation.

Any anthropogenic modifications are superimposed upon natural fluctuations which may have very long periods. This can be shown by examining the magnitude of Nile flooding about which information exists from 3000 B.C. (Riehl and Meitin, 1979). Continuous records of the annual maximum and minimum levels of the river at one location are available for the period 640-1470 A.D. (Hameed, 1984). The period 622-1976 A.D. can be described with only a few interruptions (Riehl et al., 1979; Riehl and Meitin, 1979; and Hassan, 1981). Periods from 17.3 years to more than a century appear in the data. Flooding of the Nile river is above average from the middle of the nineteenth century to 1976.

Results of several investigations document the existence of trends in precipitation for periods of a few decades to a century. Khalili's (1976) analysis of precipitation data for the years 1894-1974 at Tehran shows an increase until the early 1920's followed by a decrease until the early 1960's with a slight increase until 1974. The overall trend of Khalili's for the entire period is negative. Winstanley's (1973) investigation of mean rainfall for the rainy seasons 1951-52 through 1969-70 at several Middle Eastern stations also shows a broad minimum near 1960. Al-Najim's (1975a,c) work exhibits positive trends of thunderstorms and exceptional floods in Iraq during the 31 years 1941-1971. Maximum flooding occurs at the end of the period, but maximum thunderstorms in the early 1960's are followed by some decrease. Precipitation at Jerusalem decreases considerably from the beginning to the end of the period 1861-1960. Striem's (1979) records show mean annual precipitation of 604.9 mm up to 1900, 539.9 mm for 1901-1930, and 492.9 mm for 1931-1960. Uncertainty of what to expect in the Middle East is illustrated by the fact that Takahashi and Arakawa (1981) list mean annual precipitation of 627.1 mm for the years 1952-1965 at Jerusalem. Short term uncertainty may be decreased somewhat by using various forecasting techniques (Krown, 1966; Ali, 1953).

Precipitation measurements correlate inversely with temperature measurements at Jerusalem (Striem, 1979, 1981), and the overall trend of temperature from 1861 to 1960 is positive at Jerusalem. The annual mean is 16.9°C for 1861-1900, 17.0°C for 1901-1930, and 17.3°C for 1931-1960. The annual mean temperature at Jerusalem for 1952-1965 is 16.6°C according to Takahashi and Arakawa (1981). According to newer temperature data which will be discussed in the following section of this report, the annual mean temperature at Jerusalem for the period 1973-1981 is 16.2°C.

III. TEMPERATURE, DEW POINT, AND HUMIDITY

At most locations in the Middle East, both temperature and dew point have seasonal variations which are out-of-phase with the variation of rainfall. The dew point of a parcel of moist air is the temperature to which it must be cooled at constant pressure to become saturated. The water vapor content of air increases almost exponentially with dew point, and saturation is seldom reached during the hot summers in the Middle East. However, dew points and absolute humidities are higher in summer than in winter. Extreme dew points above 32°C have been recorded in summer along the coastal areas of the Persian Gulf and the Red Sea (Howe et al., 1968; Dodd, 1969; and Riordan, 1974). These are among the highest in the world, and dew points above 25°C are fairly common in summer in these coastal areas. Furthermore, absolute humidities aboard a ship in the Red Sea and the Gulf of Aden are higher than those in a commonly used model of the tropical atmosphere (Tomasi, 1984). Turner (1978) and Shehadeh (1984) show that the climate along the Persian Gulf (which they call the Arabian Gulf) has a high discomfort index during the warmer half of the year, but winter is comfortable.

Table 3 contains frequency distributions of temperature for January, April, July, and October at three stations from Dodd's (1969) study of high dew points and associated temperatures throughout the world. Abadan (30°20'N, 48°18'E) and Dhahran (26°17'N, 50°09,E) have very hot summers. The median temperature in July is 37.9°C at Abadan and 35.2°C at Dhahran. Cairo (30°02' N, 31°15'E) is cooler with a median July temperature of 28.1°C. Ten percent of the temperatures in July are above 43.9°C, 41.8°C, and 35.1°C at Abadan, Dhahran, and Cairo, respectively, and ninety percent are above 28.9°C, 30.2°C, and 22.7°C. All three stations are much cooler in January when median temperatures are 13.4°C and 13.2°C at Abadan and Cairo and 15.6°C at Dhahran. April and October have temperatures intermediate between those in January and July. October is a little warmer than April at all three stations.

Billions' (1972) investigation of frequencies and durations of surface temperatures in hot and dry regions includes analysis of 84 stations, of which 17 are in the Middle East. In her table of values equaled or exceeded one percent of the time, the highest value is 119°F(48.3°C) which occurs in Saudi Arabia in July. Twelve of the 84 stations have one-percent values of at least 115°F(46.1°C) in some months, and six of these are in the Middle Eastern countries of Iran, Iraq, and Saudi Arabia. The highest temperature equaled or exceeded five percent of the time is the 116°F(46.7°C) which occurs in Saudi Arabia in July. Temperatures seldom remain as high as 115°F (46.1°C) more than eight hours, and durations near four hours are typical. Because the diurnal variation of temperature at these very hot stations is large, durations of temperatures greater than or equal to 100°F(37.8°C) are always less than 24 hours.

Table 3 also contains frequency distributions of dew point for the four midseason months, and these are generally higher than those in most parts of the world. Medians in July are comparable to each other at the three stations, but maximum dew points are higher at Abadan and Dhahran than at Cairo. Median dew points in July are 17.7°C at Cairo, 18.4°C at Dhahran, and 19.2°C at Abadan. Ten percent are greater than 26.7°C at Abadan and 27.3°C at Dhahran in July, but the corresponding threshold value is only 20.6°C at

Cairo. Dew points are between 10 and 13°C less in January than in July at Abadan and Cairo. Dew points in April and October are comparable to each other and are approximately midway between January and July for all percentiles at Abadan. Dew points at Cairo are slightly less in October than in July, and those in April are a little higher than the dew points in January. The median dew point is higher in October than in July at Dhahran where the median is 20.5°C in October and 18.4°C in July. The standard deviation of dew point at Dhahran is larger in July than in October, and maximum values occur in July. Dew points at Dhahran are rather high even in January when the median is 10.0°C, and ten percent are greater than 15.0°C.

Diurnal variations of surface temperature and dew point at the standard observational level of 2 m are quite large at many locations in the Middle East. Minimum temperatures occur near sunrise, and maxima occur in the afternoon. Observations of dew points from several stations in the Middle East show evidence of a double oscillation which is described in textbooks (Godske et al., 1957; Petterssen, 1958). This double oscillation is caused by changes in vertical transport associated with the diurnal variation of atmospheric stability. The minimum dew point in the morning coincides with the minimum temperature. The decrease of stability when the surface temperature increases after sunrise causes evaporation and upward transfer of water vapor from the ground. Initially the vapor accumulates in a layer near the ground, and a maximum amount exists between 0800 and 1000 hours local time. Continued surface heating after this time causes the lapse rate to become so steep that vertical exchange extends through a much deeper layer while the ground has become much drier. A second minimum dew point occurs in the afternoon at approximately 1500 hours. Convection diminishes as surface heating decreases, and a second maximum dew point occurs between 3 and 4 hours after sunset. During the night there is a flux of water to the ground, and the dew point decreases until sunrise.

Three-hourly means and standard deviations of temperature and dew point for each season at Dhahran (26°16'N, 50°10'E) are listed in Table 4. Values in this table were obtained by analyzing raw data on magnetic tape received from the USAF Environmental Technical Applications Center (ETAC). Minimum temperatures occur at 0600 hours, and maxima occur at 1200 or 1500 hours. The range of the three-hourly temperatures is approximately 11°C in summer and fall, 10°C in spring, and 8°C in winter. Each hour has the smallest standard deviation of temperature in summer and the largest in spring. Standard deviations of temperature vary from 2.0°C to 6.0°C. The mean diurnal range of dew point is much smaller than the range of temperature. The mean daily minimum dew point in winter is 10.0°C which occurs at 0600 hours, and a secondary minimum of 10.1°C occurs at 1500 hours. The highest mean dew point in winter at Dhahran is 11.9°C at 2100 hours, and a secondary maximum is 10.5°C at 0900 hours. The double cycle is not evident during the other three seasons when the minimum is at noon and the maximum at 2100 hours. The largest difference of mean dew point between 2100 hours and 1200 hours is 6.5°C which exists in summer when the maximum is 20.5°C and the minimum is 14.0°C. Mean dew points are lowest in winter at each of the eight three-hourly observation times. Summer has the highest values at 0000 hours and 2100 hours, but mean dew

points are highest in fall at the other six observation times. Standard deviations are largest in summer and smallest in winter at every hour. They vary from 4.0°C to 7.4°C. Because standard deviations are considerably larger in summer than in fall, maximum dew points are expected in summer. This is consistent with the findings of Dodd (1969).

Means and standard deviations of temperature and dew point at three-hourly intervals at Tel Aviv, Israel, are listed in Table 5. Tel Aviv is a little cooler than Dhahran in winter and much cooler in summer. Standard deviations of temperature are lower at Tel Aviv than at Dhahran throughout the year. Mean dew points at Tel Aviv are a few degrees lower than those at Dhahran in all seasons except summer when Tel Aviv has higher mean dew points from 0600 hours to 1800 hours. The minima in the double cycle of mean dew point at Tel Aviv in summer are 17.0°C at 0600 hours and 17.8°C at 1500 hours, and the maxima are 18.6°C at 0900 hours and 19.3°C at 2100 hours. The dew point at Tel Aviv has a double cycle in all seasons except winter, but the magnitudes of the diurnal range are small during the entire year. Standard deviations of dew point at Tel Aviv are less than half as large as those at Dhahran in summer, and they are slightly smaller in winter and spring. Differences between standard deviations of dew point at Dhahran and Tel Aviv are very small in fall.

Table 6 contains means and standard deviations of temperature and dew point at three-hourly intervals at Jerusalem. Because Jerusalem is at an elevation of 809 m, it is not surprising that it is cooler and drier than Tel Aviv at 41 m. Temperatures and dew points are consistently a few degrees lower at Jerusalem. Standard deviations of dew point are higher at Jerusalem throughout the year, and the difference is quite large in summer.

Baghdad, Iraq, has very large diurnal ranges of temperature. Table 7 shows that in summer the mean is 41.4°C at 1500 hours and 24.8°C at 0600 hours based on data from the years 1973-1980. Average daily maxima are 40.2°C, 43.0°C, and 43.3°C for June, July, and August according to Normand's (1919) analysis of data from Baghdad for the period 1888-1918. Normand reports averge daily minima of 24.3°C, 26.4°C, and 25.8°C during the three summer months. Normand does not make clear if a max-min thermometer was used or if hourly data were used. The means in winter according to our data are 16.2°C at 1500 hours and 6.0°C at 0600 hours. Normand's data for December, January, and February show average daily maxima of 17.1°C, 15.0°C, and 18.4°C and average daily minima of 5.7°C, 3.5°C, and 6.0°C. The standard deviation of temperature at 0600 hours in winter is 4.3°C at Baghdad, and therefore temperatures can be expected to be below freezing on several winter days. Baghdad has an average of 17 days of frost per year according to data from the years 1941-1971 (Al-Najim, 1975b). Frost is a problem for agriculture in most of Iraq and more than 20 days per year occur in part of the northeastern section of the country.

There is evidence of a double oscillation of dew point in all seasons at Baghdad, but the times of some maxima and minima do not fit the conventional pattern. In winter the mean minimum dew point is 3.0°C at 0600 hours, and a secondary minimum of 4.7°C occurs at 1500 hours. The highest mean dew point in the three-hourly data at Baghdad in winter is 5.3°C at noon which is late. A secondary maximum of 5.0°C at 1800 hours in winter is earlier than the

typical time. Highest mean dew points in the three-hourly data from Baghdad for the other three seasons occur at 0900 hours, and secondary maxima occur at 2100 hours. The highest mean for the year is 10.0°C at 0900 hours in summer. The lowest mean dew points in summer and fall are 5.2°C and 4.9°C, respectively, and they occur at 1500 hours. In spring the lowest is the 4.7°C at 1800 hours.

Table 8 contains three-hourly seasonal means and standard deviations of temperature and dew point for Tehran, Iran. The seasonal variation of temperature is very large at Tehran. The mean at 1500 hours is 34.8°C in summer and 6.9°C in winter. The difference between summer and winter is slightly smaller at 0600 hours when the mean temperature is 24.7°C in summer and 0.6°C in winter. The seasonal variation of dew point is much smaller, and the diurnal fluctuations are very small. In winter the lowest mean dew point is -3.9°C at 0600 hours, and the highest is -3.0°C at 1800 hours and 2100 hours. In spring the lowest mean dew point is -1.3°C at 1500 hours and the highest is 0.9°C at 0900 hours. In fall the lowest mean dew point is -0.8°C, and the highest is 1.0°C. The diurnal variation of mean dew point at Tehran is also very small in summer when the highest is 5.5°C at 0900 hours and the lowest is 4.1°C at 1800 hours.

Tables 9-13 describe the seasonal three-hourly variation of absolute humidity at the five stations for which temperature and dew point are listed in Tables 4-8. Tables 9-13 include maxima, minima, means, and standard deviations of absolute humidity. Dhahran is the station which has the highest means in winter, spring, and fall, but Tel Aviv has higher means from 0900 hours to 1500 hours in summer. Tehran has lower mean absolute humidities than the other four stations at all hours in all seasons. Tehran is so much drier than Dhahran in winter that the means near 4 grams per cubic meter at Tehran are approximately the same as the minima at Dhahran. In winter the means at Dhahran at all hours are near 10 grams per cubic meter, but maxima at Tehran are less than or equal to this value. In summer at Tehran mean absolute humidities are near 7 grams per cubic meter at all hours. In summer at Dhahran the large diurnal range of means includes a low of 12.9 grams per cubic meter at noon and a high of 18.7 grams per cubic meter at 2100 hours. Dhahran has higher standard deviations than the other four stations at all hours in all seasons. The maxima for Dhahran in Table 9 are higher than those at the other stations in all seasons. The determination of these extreme values involves some subjectivity in the decision concerning which outliers should be considered erroneous. Dodd (1969) has accepted dew points of 89°F (31.7°C) at Dhahran with simultaneous temperatures from 91°F to 102°F (32.8°C - 38.9°C). This corresponds to an absolute humidity of 33 grams per cubic meter. The maximum of 37 grams per cubic meter in Table 9 corresponds to a dew point which is only about two degrees Celsius higher. Determination of maxima at Tehran is very subjective because this stations has very poor data. There is no precise method to define an upper limit of absolute humidity, but the lower limit must be positive. Therefore, many distributions are skewed at all stations. This is especially true in the summer when the difference between the maximum and the mean is usually larger than the difference between the mean and the minimum.

IV. VISIBILITY

The diurnal frequency of low visibilities is bimodal in much of the Middle East. Fogs typically occur in the early morning hours and begin to dissipate at sunrise. Dust storms are most frequent from noon to 1500 hours when vertical mixing is strongest. Aerosols can remain in the air as long as vertical velocity fluctuations are greater than the terminal velocity of the falling particles (Gillette et al., 1974; Gillette and Goodwin, 1974).

Fog occurs when suspended drops of water near the surface of the earth cause atmospheric visibility to be reduced below 1 km (Huschke, 1959). Information on fog drop-size distribution in the Middle East is not available. Extensive general information about fog at many other locations throughout the world is discussed in a survey article by Stewart and Essenwanger (1982).

A dust storm is usually defined as a condition where sand or dust in the atmosphere reduce visibility below 1 km. Hinds and Hoidale (1975) also define a condition of blowing dust when the visibility is below 11 km. Their report contains the monthly three-hourly frequency of these conditions for 135 stations.

The size of desert dust typically has a bimodal distribution (D'Almeida and Schütz, 1983; Holst et al., 1982; Patterson and Gillette, 1977b; and Schütz and Jaenicke, 1974). One modal radius of volume distributions is typically a few micrometers, and another is in the range 20-50 micrometers.

Sowelim's (1983) measurements at Cairo, Egypt, indicate that a strong relationship exists between mean wind speed and median particle diameter. On the other hand, Kushelevsky et al. (1983) obtain a weak relationship between the amount of suspended particulate matter and wind speed at Beer-Sheva, Israel. There appears to be no simple formula to relate wind speed to aerosol concentration in the desert. Hanna (1969) describe types of wind patterns associated with the formation of sand dunes. Hanna's article includes pictures of desert areas in Saudi Arabia and Iran.

Hinds and Hoidale (1975) recommended the following formula to obtain concentration C in micrograms per cubic meter as a function of visibility V in kilometers:

$$C = \frac{56000}{V^{1.25}}$$

According to their formula, a dust particle concentration of 56000 micrograms per cubic meters is associated with a visibility of 1 km. The above formula gives a concentration of almost 2800 micrograms per cubic meter for a visibility of 11 km. Patterson and Gillette (1977a) discuss visibility versus mass concentration for several locations in the world, and the above formula is not always reliable. They consider another formula where the exponent of V is unity. The above formula certainly does not seem to be reliable at Beer-Sheva, Israel, where Kushelevsky et al. (1983) measured total suspended

particle (TSP) concentration for one year. Levels of TSP at Beer-Sheva were mostly 500 to 800 micrograms per cubic meter during dust storms. The highest TSP level in the measurement of Kushelevsky et al. is 5080 micrograms per cubic meter, and the second highest is 1600 micrograms per cubic meter.

Table 14 contains three-hourly cumulative frequency distributions of visibility at Baghdad, Iraq. Winter has the greater frequency of visibilities less than or equal to 0.62 mi (1 km), and fall has the least. A biomodal diurnal variation of frequency is evident in these low visibilities. In winter a minimum of 1.5 percent at 1200 hours occurs between 6.7 percent at 0900 hours and 2.7 percent at 1500 hours. In summer 0.9 percent at 0900 hours comes between 1.4 percent at 0600 hours and 2.0 percent at 1200 hours. Three maxima of visibilities less than or equal to 1 km exist at Baghdad in spring. The maximum at midnight is explained in studies of Al-Najim (1975a,c). Spring dust storms are usually associated with thunderstorms, especially those at night, and midnight thunderstorms occur frequently. Baghdad has an average of 17 dust storms per year and 113 cases of blowing dust (Hinds and Hoidale, 1975). The diurnal variation of frequency of visibilities less than or equal to 3 mi (4.83 km) is much simpler. The largest number of these visibilities occurs at noon in summer and at 0900 hours in the other three seasons. Visibility is greater than 3 mi in spring and summer more than 90 percent of the time at all hours. In fall more than 10 percent of visibilities are less than or equal to 3 mi only at 0900 hours. In winter at 0900 hours almost one-third of visibilities are less than or equal to 3 mi. Visibilities greater than 10 mi (16.1 km) occur less than one-half of one percent of the time.

Table 15 contains three-hourly cumulative frequency distributions of visibility at Dhahran, Saudia Arabia. A distinct bimodal distribution of visibilities less than or equal to 1 km occurs only in summer when the 2.3 percent at 0600 hours and 2.8 percent at 1500 hours are separated by 1.2 percent at 0900 hours and 2.5 percent at 1200 hours. This is consistent with Hinds and Hoidale's (1975) study which finds that dust storms at Dhahran are most frequent in June and July. In fall and winter, visibilities less than or equal to 1 km occur primarily at 0300 hours and 0600 hours. Nearly all visibilities at Dhahran are less than 10 mi (16.1 km). This is not surprising considering the large amount of dust in the air. There are 22 dust storms and 116 cases of blowing dust per year according to Hinds and Hoidale. Atmospheric pollution by humans is also a problem in Saudi Arabia just as it is elsewhere (Newell et al., 1981).

Three-hourly frequency distributions of visibility at Jerusalem and Tel Aviv, Israel, are contained in Tables 16 and 17. Dust storms are rare at both stations and generally occur in the spring. Blowing dust occurs 24 times per year at Jerusalem and 5 times per year at Tel Aviv. Anthropogenic urban effects are important in Israel according to Levin and Lindberg (1979). Their measurements in the city of Tel Aviv contrast sharply with observations at Mitzpe Ramon in the Negev Desert. The aerosol concentration at Tel Aviv in winter is one order of magnitude larger than the concentration at Mitzpe Ramon. Nevertheless visibilities below 1 km are not frequent at Tel Aviv. Frequencies are less than 1.0 percent at all hours in fall and winter. The maximum is 1.8 percent at 0600 hours in spring. On the other hand, the

largest percent of low visibilities at Jerusalem occur in winter when 4.3 percent at 0900 hours are less than or equal to 1 km. Visibilities greater than 10 mi (16.1 km) are more frequent at both Jerusalem and Tel Aviv than at Dhahran or Baghdad. These large visibilities are most probable from 0900 hours to 1800 hours. More than 20 percent of visibilities at Jerusalem are greater than 16.1 km at noon in spring and fall. The largest number of visibilities greater than 16.1 km at Tel Aviv is 17.1 percent at 1500 hours in winter.

Table 18 contains three-hourly frequency distributions of visibility at Tehran, Iran. Visibilities less than or equal to 1 km are rare except in winter which has a maximum of 4.1 percent at 0900 hours and a minimum of 1.7 percent at 1800 hours. Visibilities greater than 16.1 km occur more often than at Dhahran and Baghdad, but they are not common. The most frequent occurrence of these high visibilities is 8.7 percent at 1500 hours in spring. It may be worth pointing out that the low incidence of dust storms (0.1 per year) is not representative of all of Iran. Abadan has 25 dust storms per year.

V. SOLAR ENERGY AND CLOUDS

World maps of total solar radiation (direct plus diffuse) are available in Löf et al. (1966) and De Jong (1973). More recent detailed information for a few stations will also be discussed in this section.

Total radiation at the surface in June is quite high in the Middle East. The maximum is more than 700 calories per square centimeter per day (700 Langleys/day) in Iran and Iraq. The minimum is between 500 and 550 Langleys/day in the southwestern part of the Arabian Peninsula (Löf et al., 1966). This agrees well with data for Baghdad in Abbas and Elnesr (1981), but the values for Iraq are slightly higher than those which are given in graphical form in Ahmad et al. (1983). They are also higher than the total radiation data for June which are recorded by Daneshyar (1978) who lists means for several stations in Iran. The highest in June is 680 Langleys/day at Isfahan and the lowest is 486 Langleys/day at Ramsar. Sfeir's (1981) data for Lebanon in June contain a value of 626 Langleys/day for the coastal region and 710 Langleys/day for the interior. The total radiation in June at Beer-Sheva, Israel, is 638 Langleys/day according to Kudish et al. (1983).

Solar radiation at the surface of the earth in December is less than half as large as in June in much of the Middle East (Löf et al., 1966). Variation in December is from less than 200 Langleys/day in northern Iran to more than 400 Langleys/day in southwestern Saudi Arabia. This is consistent with observations of Daneshyar (1983) for Iran in December when total radiation varies from 171 Langleys/day at Bandar Pahlavi to 321 Langleys/day at Chahbahar. In Iraq in December, variation is from 160 Langleys/day in the northern part to 315 Langleys/day in the extreme south according to Ahmad et al. (1983). The total solar radiation at Beer-Sheva, Israel, is only 224 Langleys/day in December according to Kudish et al. (1983). Sfeir's (1981) observations for Lebanon in December show little difference between the coastal and interior regions. Total radiation is 196 Langleys/day along the coast and 201 Langleys/day in the interior. It follows that cloud amounts in the coastal and interior parts of Lebanon are approximately the same in December.

Tables 19-23 contain three-hourly seasonal frequency distributions of cloud amount at five stations. Clear skies predominate in the Middle East in summer, and they occur frequently in winter.

At Baghdad in summer skies are clear an average of 89 percent of the time. The most clouds occur in the afternoon at 1500 hours when skies are clear 86.70 percent of the time in summer and in the morning at 0600 hours when skies are clear 85.85 percent of the time. Fewest clouds occur at Baghdad at 0300 hours in summer when the sky is clear 92.20 percent of the time. Overcast and obscure skies occur less than one percent of the time at Baghdad in summer.

Baghdad is not an unusually cloudy place in fall, winter, or spring. Overcast and obscure skies are most common in winter when they occur approximatel 14 percent of the time. Overcast and obscure skies occur less than 3 percent of the time in fall and less than 9 percent of the time in spring. Diurnal range of the percent of clear skies at Baghdad is large in winter. Clear skies in winter are most frequent at 0300 hours when 38.13 percent are

clear. Clear skies in winter are least common at 1800 hours when Baghdad skies are clear only 12.74 percent of the time. The percent of clear skies in spring is a little larger than in winter except at 0600 hours when 37.82 percent are clear in winter and 26.42 percent are clear in spring. In fall at Baghdad, skies are clear more than half of the time. The most occur at 0300 hours with 70.06 percent and the least at 1800 hours with 48.61 percent.

Dhahran has fewer clear skies than Baghdad during part of the year, but it also has a smaller amount of obscure and overcast skies. Our data for Dhahran were checked for consistency with Sherr et al. (1968) and Brown and Jeffries (1985). Even in winter sky cover is less than or equal to seven-eighths more than 93.0 percent of the time at Dhahran. Skies are clear in winter slightly less than one-third of the time from 0900 hours to 1800 hours and more than one-half of the time from 2100 hours to 0300 hours.

Clear skies prevail more than half the time in summer at Jerusalem and are common during the rest of the year. The smallest amount of clear skies occurs in winter at 1500 hours when the amount is only 12.81 percent. The diurnal range is large in winter at Jerusalem, and skies are clear 44.09 percent of the time at 0600 hours. Less than one percent of skies are overcast or obscured at Jerusalem in summer, and even in winter the amount is only 15 percent.

Tel Aviv is much cloudier, and even in the summer clear skies occur less than one-fifth of the time from 0600 hours to 0900 hours. At 0300 hours there is little seasonal variation in the percent of clear skies at Tel Aviv, but the amount of obscure and overcast is much larger in winter than in summer. At 0600 hours clear skies are more than twice as likely to occur in fall and winter than in summer, and overcast and obscured skies are four times as probable in winter as in summer. In the afternoon clear skies are many times more probable in summer than winter at Tel Aviv.

At Tehran clear skies are least likely in spring at all hours. At 1500 hours in spring the probability of clear skies is only 3.22 percent. The probability of clear skies in spring is only 27.45 percent when it reaches its largest diurnal amount at 0300 hours. In summer the probability of clear skies is less than one-half from noon to midnight.

Christensen (1983) discusses the probability that clouds are absent at different altitudes in several regions. The lowest probabilities of clear skies exist between 6500 ft (1981 m) and 14000 ft (4267 m) above mean sea level in the Middle East. In summer probabilities of clear skies in desert and mountainous regions do not differ greatly at any altitude. In winter clear skies are much less probable in mountainous regions, and this is especially true for airplanes flying at higher altitudes.

VI. WIND SPEED

Basic characteristics of wind in the Middle East are the same as those in other parts of the world. Winds are normally strongest in the early afternoon when the atmosphere is least stable. The instability causes turbulent mixing of slowly moving air near the surface with more rapidly moving air aloft. It follows that winds should be weakest just before sunrise when the atmosphere is most stable.

The development of land and sea breezes at stations near water causes the standard diurnal variation of wind speed to be modified. An effect can be produced by bodies of water which are not as large as the Mediterranean Sea or the Persian Gulf. The Dead Sea develops its own sea breezes (Bitan, 1974, 1977). Lake Kinneret (Sea of Galilee) is more shallow and covers a smaller area in the Jordan Rift Valley, but it is also important (Bitan, 1981; Asculai et al., 1984). The wind system in this area is very complicated because of the interaction of the lake breeze, sea breezes from the Mediterranean, and the mountain valley wind.

Tables 24-28 contain seasonal three-hourly mean wind speeds and standard deviations. Wind speeds in these tables follow typical patterns.

The diurnal variation of wind speed at Jerusalem is largest in summer and smallest in winter. The lowest mean wind speed in winter is 3.21 m/sec at 0600 hours and the highest is 5.30 m/sec at 1500 hours. The lowest mean in summer is 3.03 m/sec at 0600 hours and the highest is 7.18 m/sec at 1800 hours. Early morning winds are lightest in fall when the mean speed at 0600 hours is only 1.95 m/sec. The mean speed at 0600 hours in spring is 2.66 m/sec. Highest mean speeds in spring and fall occur at 1800 hours, and magnitudes are between those in summer and winter. Standard deviations of wind speed at Jerusalem have a small diurnal range. Standard deviations are much smaller in summer when they range from 1.92 m/sec to 2.39 m/sec than in winter when they range from 3.48 m/sec to 3.75 m/sec. Magnitudes of standard deviations in spring are between those in summer and winter. This is also true in fall except at 0600 hours when the standard deviation in summer is 2.39 m/sec and the one in fall is 2.27 m/sec.

Wind speeds and standard deviations are usually lower at Tel Aviv than at Jerusalem, and seasonal variations are smaller at Tel Aviv. Largest mean speeds occur at 1500 hours in all seasons at Tel Aviv. The magnitudes are 4.65 m/sec, 5.69 m/sec, 5.32 m/sec, and 5.15 m/sec in winter, spring, summer, and fall respectively. Speeds drop off sharply between 1800 hours and 2100 hours in all seasons. This is most apparent in summer when the speed is 4.66 m/sec at 1800 hours and 1.98 m/sec at 2100 hours. Speeds decrease slightly from 2100 hours to 0000 hours after which they change little for a few hours.

The diurnal range of wind speed at Dhahran is larger than it is at Jerusalem. The mean in summer at Dhahran is 7.51 m/sec at 1500 hours and 2.75 m/sec at 2100 hours. This is a difference of 4.76 m/sec. Even in winter the range is 2.23 m/sec between 5.28 m/sec at 1500 hours and 3.05 m/sec at 0000 hours. Lowest mean speeds occur at 0000 hours in every season except summer at Dhahran.

The seasonal variation of diurnal range of speeds is somewhat smaller at Baghdad than at the other stations. The range in winter is 2.53 m/sec, the difference between 4.50 m/sec at 1500 hours and 1.97 m/sec at 0600 hours. The range in summer is 3.84 m/sec, the difference between 6.84 m/sec at 1500 hours and 3.00 m/sec at 2100 hours. Fall and spring have intermediate values.

Mean daily minimum wind speeds are lower at Tehran than at Baghdad throughout the year, and maxima are lower at Tehran except in spring. Tehran is unusual because the diurnal range in spring is considerably larger than the diurnal range in the other seasons. The difference between the mean of 5.46 m/sec at 1500 hours and 2.10 m/sec at 0600 hours gives a range of 3.36 m/sec in spring at Tehran. The ranges are 2.13 m/sec, 2.15 m/sec, and 2.20 m/sec in winter, summer, and fall.

VII. SUMMARY

The most variable characteristic of climate in the Middle East is precipitation. The summer is dry in almost the entire region, but the total annual precipitation varies considerably. Mean annual rainfall is less than 40 mm in most of Egypt and the Arabian Peninsula and in parts of Israel and Jordan. Mean annaul rainfall exceeds 1000 mm in parts of Lebanon, Syria, Iran, and Iraq. Year-to-year variability is more than 40 percent in most of the Middle East and more than 20 percent in almost the entire region. Sporadic rain in the driest regions usually comes in the form of heavy showers which often cause floods.

Temperatures are high in summer in most of the Middle East, and dew points are also high in many areas. Extreme dew points along the coastal areas of the Persian Gulf and the Red Sea are among the highest in the world. Mean absolute humidities in summer and fall at Dhahran, Saudi Arabia, are greater than 15.0 grams per cubic meter, and humidities greater than 30.0 grams per cubic meter are expected from time to time.

Fog and pollution reduce visibility in the Middle East just as elsewhere, and dust storms are an additional problem in most of the region. Blowing dust is common, and in many areas visibilities greater than 10 mi (16.1 km) are rare. The diurnal variation of low visibilities is bimodal in much of the Middle East. Fogs are most frequent just before sunrise, and dust storms are most severe in the early afternoon.

Insolation in the Middle East is high throughout the region in June but is low in the northern areas in December. In northern Iran the total solar radiation at the surface is slightly below 700 Langleys/day in June and is below 200 Langleys/day in December. In southwestern Saudi Arabia the change from June to December is from about 500 Langleys/day to a little more than 400 Langleys/day. Skies are clear at least half of the time in summer in most of the Middle East. At Baghdad, Iraq, summer skies are clear 89 percent of the time.

Winds in the Middle East are strongest in the afternoon and weakest sometime between sunset and sunrise. In many places winds are weakest a short time before sunrise when the atmosphere is most stable. In other locations, the diurnal cycle is influenced by land and sea breezes or by mountain and valley winds.

Topography and distance from water affect all climatic elements to some extent. The terrain in the Middle East is not at all uniform. The width of coastal plains varies considerably from place to place. The rift in the Jordan Valley reaches a depth of nearly 400 m below sea level near the Dead Sea, and mountains are on each side of the rift. Even higher peaks exist in the Elburz and Zagros mountains in Iran. Major portions of Iran, Syria, and the Arabian Peninsula are plateaus. This diversity in the land is reflected in diversity in the climate.

TABLE 1. Representative Sample of Stations Which Illustrate Year-To-Year Variability of Annual Precipitation in the Middle East.*

Station	Latitude	Longitude	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
			Year									
			Annual Precipitation (Millimeters)									
Alexandria	31°12'N	29°57'E	153	130	166	246	205	181	307	116	205	175
Cairo(Airport)	30°08'N	31°34'E	73	17	12	15	10	19	60	3	22	15
Bahrain	26°16'N	50°37'E	61	23	78	105	169	29	111	77	164	10
Dhahran	26°17'N	50°09'E	67	32	122	106	148	32	108	76	154	11
Tel Aviv	32°06'N	34°47'E	609	467	663	812	676	398	668	231	382	444
Beer-Sheva	31°14'N	34°47'E	221	149	267	249	121	234	237	66	185	93
Amman	31°57'N	35°57'E	304	188	435	240	205	216	404	136	229	146
Beirut	33°49'N	35°29'E	800	661	787	605	469	423	597	297	474	477
Tripoli	34°35'N	36°00'E	711	759	1227	903	622	838	717	609	616	651
Damascus	33°29'N	36°14'E	224	248	430	310	191	144	245	155	262	130
Baghdad	33°20'N	44°24'E	266	73	98	278	168	93	338	125	172	79
Kirkuk	35°28'N	44°24'E	282	323	477	501	341	207	593	186	328	324
Abadan	30°22'N	48°15'E	131	148	145	321	113	94	168	81	102	85
Tehran	35°41'N	51°19'E	266	265	232	275	207	190	371	168	198	147

* Data are from World Weather Records, 1951-60 (Environmental Science Services Administration, 1966, 1967a,b).

TABLE 2. Year-To-Year Variation of Precipitation in January at the Stations Listed in TABLE 1.

Station	Year									
	51	52	53	54	55	56	57	58	59	60
	Precipitation in January (millimeters)									
Alexandria	33	35	32	12	1	64	80	53	64	71
Cairo	0	3	0	0	2	0	15	2	2	10
Bahrain	3	7	2	1	67	17	35	40	136	1
Dhahran	4	5	2	1	28	18	19	57	127	3
Tel Aviv	81	149	160	118	28	136	144	164	106	162
Beer-Sheva	22	61	4	15	9	54	59	52	12	19
Amman	28	36	29	18	14	66	101	107	67	31
Beirut	120	110	172	134	39	99	91	127	188	126
Tripoli	159	115	250	357	64	238	130	280	215	147
Damascus	19	20	148	70	6	45	69	71	61	27
Baghdad	37	8	5	14	54	8	12	74	5	28
Kirkuk	41	7	66	16	63	33	52	38	9	69
Abadan	61	32	5	3	12	12	18	17	23	15
Tehran	56	17	17	27	55	10	51	27	48	8

TABLE 3. Frequency Distributions of Temperature (°C) and Dew Point (°C) During the Midseason Months at Three Middle Eastern Stations (Dodd, 1969).

Station	Month	Temperature Percentile					Dew Point Percentile				
		10	30	50	70	90	10	30	50	70	90
Abadan	January	6.2	10.6	13.4	16.2	20.0	0.3	5.3	7.9	10.4	13.7
	April	18.3	22.4	25.7	29.4	33.4	6.1	10.8	13.4	15.7	18.6
	July	28.9	33.7	37.9	42.3	43.9	11.6	16.1	19.2	22.4	26.7
	October	18.3	23.4	28.2	32.9	36.8	7.7	11.7	13.9	16.4	19.8
Cairo	January	9.3	11.7	13.2	15.3	17.9	1.7	4.4	6.1	7.7	9.8
	April	13.7	16.7	20.0	23.3	28.4	2.8	6.3	8.8	10.7	12.3
	July	22.7	24.8	28.1	31.7	35.1	11.9	15.6	17.7	19.4	20.6
	October	18.2	20.9	23.4	26.0	29.5	10.1	12.2	13.8	15.7	18.3
Dhahran	January	11.1	13.8	15.6	17.4	20.2	4.1	7.8	10.0	12.1	15.0
	April	20.0	22.9	25.1	27.8	32.2	6.2	11.1	14.0	16.7	19.7
	July	30.2	32.6	35.2	38.3	41.8	9.4	14.1	18.4	23.2	27.3
	October	23.9	26.1	28.3	31.1	34.4	12.8	17.8	20.5	22.3	24.0

TABLE 4. Diurnal Variation of Means and Standard Deviations of Temperature (T) and Dew Point (TD) in Degrees Celsius at Dhahran (26°16'N, 50°10'E, 23m), Saudi Arabia, for the Period 1973-1981.

Local Time	Variable	Season Winter	Spring	Summer	Fall
0000	Mean T	14.8	22.5	30.8	24.2
	σ(T)	3.2	5.1	2.7	4.5
	Mean TD	11.4	15.0	19.9	19.4
	σ(TD)	4.1	4.7	6.1	5.4
0300	Mean T	13.4	20.8	29.5	22.7
	σ(T)	3.6	4.9	2.6	4.5
	Mean TD	10.6	14.4	17.9	18.3
	σ(TD)	4.5	4.8	6.6	5.8
0600	Mean T	12.9	20.7	29.3	21.8
	σ(T)	3.6	5.1	2.5	4.6
	Mean TD	10.0	13.9	15.9	16.4
	σ(TD)	4.6	5.0	7.4	6.4
0900	Mean T	15.8	26.6	36.3	27.9
	σ(T)	3.4	5.8	2.0	5.3
	Mean TD	10.5	13.0	14.5	15.8
	σ(TD)	4.8	5.1	7.2	6.9
1200	Mean T	20.2	30.2	40.2	32.6
	σ(T)	3.4	6.0	2.8	5.3
	Mean TD	10.4	11.5	14.0	14.4
	σ(TD)	4.6	5.5	6.8	6.0
1500	Mean T	20.9	30.0	39.7	32.6
	σ(T)	3.2	5.8	2.2	5.0
	Mean TD	10.1	11.8	15.2	15.8
	σ(TD)	4.6	5.7	6.4	5.5
1800	Mean T	18.6	27.2	36.5	29.0
	σ(T)	2.9	5.4	2.1	4.9
	Mean TD	11.6	13.7	18.0	19.0
	σ(TD)	4.1	5.1	6.1	5.0
2100	Mean T	16.2	24.3	32.8	26.1
	σ(T)	2.8	4.9	2.0	4.5
	Mean TD	11.9	15.1	20.5	20.2
	σ(TD)	4.0	4.7	6.1	5.0

TABLE 5. Diurnal Variation of Means and Standard Deviations of Temperature (T) and Dew Point (TD) in Degrees Celsius at Tel Aviv (32°00'N, 34°54'E, 41m), Israel, for the Period 1973-1981.

Local Time	Variable	Season			
		Winter	Spring	Summer	Fall
0000	Mean T	11.4	15.5	22.6	19.0
	σ(T)	2.8	4.1	2.1	3.7
	Mean TD	7.3	10.9	18.5	14.1
	σ(TD)	3.3	3.4	2.6	5.0
0300	Mean T	10.4	13.9	21.1	17.8
	σ(T)	2.9	4.2	2.2	3.8
	Mean TD	6.6	9.9	17.6	13.2
	σ(TD)	3.7	3.7	2.7	5.2
0600	Mean T	9.9	13.3	20.4	17.1
	σ(T)	3.2	4.1	2.4	3.9
	Mean TD	6.3	9.4	17.0	12.8
	σ(TD)	3.6	3.7	3.4	5.0
0900	Mean T	11.3	18.1	25.7	21.4
	σ(T)	2.8	4.8	1.9	4.3
	Mean TD	6.3	10.5	18.6	13.8
	σ(TD)	3.7	4.1	2.7	5.5
1200	Mean T	16.4	22.8	29.8	26.2
	σ(T)	3.6	5.4	2.1	3.9
	Mean TD	6.7	9.3	17.9	13.5
	σ(TD)	4.3	5.2	2.9	5.7
1500	Mean T	17.9	23.8	30.4	27.0
	σ(T)	3.6	5.2	2.1	3.8
	Mean TD	6.7	9.4	17.8	14.0
	σ(TD)	4.9	5.0	3.0	5.5
1800	Mean T	16.0	22.0	28.9	24.8
	σ(T)	3.0	4.8	2.0	3.9
	Mean TD	7.9	10.0	18.3	14.7
	σ(TD)	3.9	4.0	2.9	5.1
2100	Mean T	12.8	18.0	25.0	21.3
	σ(T)	2.6	4.2	1.9	3.8
	Mean TD	8.1	11.5	19.3	15.1
	σ(TD)	3.4	3.7	2.7	5.0

TABLE 6. Diurnal Variation of Means and Standard Deviations of Temperature (T) and Dew Point (TD) in Degrees Celsius at Jerusalem (31°47'N, 35°13'E, 809m), Israel, for the Period 1973-1981.

Local Time	Variable	Season			
		Winter	Spring	Summer	Fall
0000	Mean T	7.9	12.8	19.6	16.1
	σ(T)	2.7	5.0	2.8	3.8
	Mean TD	3.6	4.8	12.3	9.7
	σ(TD)	4.6	5.0	5.8	6.3
0300	Mean T	7.4	11.9	18.6	15.3
	σ(T)	2.7	5.0	2.8	3.7
	Mean TD	3.4	4.0	11.2	9.2
	σ(TD)	3.9	5.3	6.1	6.3
0600	Mean T	7.0	11.3	18.0	14.7
	σ(T)	2.7	4.9	2.8	3.9
	Mean TD	3.1	4.1	11.5	9.0
	σ(TD)	4.1	4.8	5.8	6.1
0900	Mean T	8.0	15.1	22.4	17.9
	σ(T)	3.2	5.7	3.3	4.5
	Mean TD	3.2	3.4	10.0	8.6
	σ(TD)	4.4	5.7	6.3	6.5
1200	Mean T	10.7	18.0	26.0	21.4
	σ(T)	3.4	6.0	3.3	4.9
	Mean TD	3.1	3.2	9.9	7.1
	σ(TD)	4.5	5.6	5.0	6.4
1500	Mean T	12.0	19.5	27.5	23.0
	σ(T)	3.8	6.1	3.0	5.1
	Mean TD	3.0	4.0	11.7	7.8
	σ(TD)	4.8	5.3	4.2	6.5
1800	Mean T	10.8	18.2	25.8	20.7
	σ(T)	3.5	6.0	3.0	4.9
	Mean TD	4.0	5.1	12.3	10.0
	σ(TD)	4.9	5.2	4.4	6.2
2100	Mean T	8.8	14.6	21.2	17.4
	σ(T)	2.7	5.3	2.7	4.0
	Mean TD	4.0	6.1	14.2	10.8
	σ(TD)	4.7	5.0	4.5	6.3

TABLE 7. Diurnal Variation of Means and Standard Deviations of Temperature (T) and Dew Point (TD) in Degrees Celsius at Baghdad (33°15'N, 44°14'E, 34m), Iraq, for the Period 1973-1980.

Local Time	Variable	Season			
		Winter	Spring	Summer	Fall
0000	Mean T	8.4	19.5	29.1	19.1
	σ(T)	4.1	5.7	3.3	6.9
	Mean TD	4.2	7.1	8.0	6.2
	σ(TD)	4.1	4.5	3.5	4.4
0300	Mean T	6.7	16.7	26.1	17.0
	σ(T)	4.1	5.7	3.0	6.5
	Mean TD	3.6	6.8	8.2	5.9
	σ(TD)	4.2	4.3	3.3	4.3
0600	Mean T	6.0	15.6	24.8	15.7
	σ(T)	4.3	5.8	3.1	6.5
	Mean TD	3.0	6.9	8.6	5.4
	σ(TD)	4.8	4.1	3.5	4.3
0900	Mean T	8.4	21.8	33.2	22.6
	σ(T)	3.9	6.6	2.6	7.5
	Mean TD	4.5	7.8	10.0	6.9
	σ(TD)	4.2	4.3	3.9	4.8
1200	Mean T	13.2	26.2	38.5	29.0
	σ(T)	4.2	6.9	3.7	8.2
	Mean TD	5.3	6.4	8.0	6.4
	σ(TD)	4.4	4.9	4.5	4.9
1500	Mean T	16.2	28.7	41.4	32.0
	σ(T)	4.0	6.6	3.3	7.7
	Mean TD	4.7	4.8	5.2	4.9
	σ(TD)	5.1	5.4	4.4	5.1
1800	Mean T	14.4	27.7	40.4	28.9
	σ(T)	4.0	6.7	3.1	8.4
	Mean TD	5.0	4.7	5.4	6.5
	σ(TD)	4.6	5.3	4.1	4.6
2100	Mean T	10.2	21.6	32.2	21.6
	σ(T)	4.1	6.0	3.4	7.2
	Mean TD	4.8	7.2	8.1	6.7
	σ(TD)	4.4	4.3	3.9	4.3

TABLE 8. Diurnal Variation of Means and Standard Deviations of Temperature (T) and Dew Point (TD) in Degrees Celsius at Tehran (35°41'N, 51°19'E, 1204m), Iran, for the Period 1973-1980.

Local Time	Variable	Season			
		Winter	Spring	Summer	Fall
0000	Mean T	1.9	14.4	27.4	16.0
	σ(T)	4.4	6.3	4.0	7.6
	Mean TD	-3.3	0.2	4.9	-0.8
	σ(TD)	4.2	5.8	4.5	6.2
0300	Mean T	1.0	13.0	24.8	15.0
	σ(T)	3.9	6.1	3.9	7.1
	Mean TD	-3.8	0.4	4.6	-0.4
	σ(TD)	4.4	5.2	4.6	5.9
0600	Mean T	0.6	12.7	24.7	14.3
	σ(T)	4.3	6.5	3.9	6.9
	Mean TD	-3.9	0.8	5.0	-0.4
	σ(TD)	4.2	5.0	4.3	5.6
0900	Mean T	3.2	16.8	29.6	19.4
	σ(T)	4.2	6.7	3.6	7.5
	Mean TD	-3.2	0.9	5.5	1.0
	σ(TD)	3.7	5.0	3.9	5.3
1200	Mean T	5.7	19.0	32.3	21.7
	σ(T)	4.8	7.2	4.0	7.6
	Mean TD	-3.5	-0.2	4.9	0.1
	σ(TD)	4.1	5.4	3.8	5.8
1500	Mean T	6.9	20.9	34.8	23.3
	σ(T)	4.7	6.8	3.2	7.6
	Mean TD	-3.3	-1.3	4.3	-0.8
	σ(TD)	4.3	5.8	3.6	6.0
1800	Mean T	5.2	19.6	34.0	21.4
	σ(T)	4.6	6.6	3.3	8.1
	Mean TD	-3.0	-1.1	4.1	-0.5
	σ(TD)	4.4	5.9	3.7	5.7
2100	Mean T	2.7	16.4	29.9	17.8
	σ(T)	4.1	6.5	3.6	7.8
	Mean TD	-3.0	-0.2	4.6	-0.2
	σ(TD)	4.3	5.9	4.2	5.7

TABLE 9. Diurnal Variation of Maximum, Mean, Minimum, and Standard Deviation of Absolute Humidity in Grams Per Cubic Meter at Dhahran (26°16'N, 50°10'E, 23m), Saudi Arabia, for the Period 1973-1981.

Local Time	Variable	Season: Winter	Spring	Summer	Fall
0000	Maximum	17.3	25.8	32.1	30.4
	Mean	10.5	13.2	18.0	17.3
	Minimum	3.9	4.8	3.9	3.4
	σ	2.6	3.6	6.2	5.0
0300	Maximum	20.6	23.0	33.8	30.4
	Mean	10.1	12.8	16.2	16.3
	Minimum	4.2	4.8	5.6	2.7
	σ	2.8	3.6	6.3	5.1
0600	Maximum	17.3	23.0	33.8	28.8
	Mean	9.7	12.4	14.7	14.7
	Minimum	4.2	4.8	4.5	3.0
	σ	2.7	3.6	6.6	5.2
0900	Maximum	18.3	24.4	32.1	28.8
	Mean	10.0	11.8	13.4	14.4
	Minimum	3.4	4.2	3.4	3.2
	σ	2.9	3.6	6.2	5.7
1200	Maximum	18.3	28.8	37.0	30.4
	Mean	10.0	10.8	12.9	13.0
	Minimum	3.4	3.7	3.4	3.4
	σ	2.8	3.8	5.7	4.7
1500	Maximum	19.4	34.1	37.0	32.1
	Mean	9.8	11.1	13.8	14.0
	Minimum	3.0	3.0	4.2	4.5
	σ	2.7	4.1	5.6	4.6
1800	Maximum	19.4	32.1	33.8	30.4
	Mean	10.6	12.3	16.2	16.8
	Minimum	3.7	3.0	5.2	4.8
	σ	2.6	3.8	6.0	4.6
2100	Maximum	18.3	32.1	33.8	30.4
	Mean	10.8	13.3	18.7	18.0
	Minimum	3.7	4.8	5.2	4.8
	σ	2.5	3.8	6.2	4.9

TABLE 10. Diurnal Variation of Maximum, Mean, Minimum, and Standard Deviation of Absolute Humidity in Grams Per Cubic Meter at Tel Aviv (32°00'N, 34°54'E, 41m), Israel, for the Period 1973-1981.

Local Time	Variable	Season			
		Winter	Spring	Summer	Fall
0000	Maximum	12.1	16.3	21.8	23.0
	Mean	8.0	10.1	15.9	12.5
	Minimum	2.2	3.0	3.4	2.5
	σ	1.6	2.0	2.2	3.3
0300	Maximum	12.1	15.4	21.8	21.8
	Mean	7.6	9.5	15.1	11.9
	Minimum	0.3	1.1	3.4	1.1
	σ	1.6	2.0	2.2	3.3
0600	Maximum	11.4	15.4	20.6	20.6
	Mean	7.5	9.2	14.6	11.6
	Minimum	1.9	2.5	0.7	2.2
	σ	1.8	2.0	2.5	3.2
0900	Maximum	12.1	18.3	20.6	19.4
	Mean	7.6	9.9	15.9	12.3
	Minimum	0.4	1.2	5.2	1.1
	σ	1.6	2.4	2.3	3.5
1200	Maximum	13.6	18.3	25.8	20.6
	Mean	7.8	9.3	15.4	12.2
	Minimum	1.2	1.9	3.4	1.9
	σ	2.0	2.8	2.4	3.6
1500	Maximum	13.6	16.3	27.2	20.6
	Mean	7.9	9.3	15.3	12.5
	Minimum	0.5	0.4	5.2	2.0
	σ	2.2	2.6	2.6	3.5
1800	Maximum	13.6	15.4	25.8	21.8
	Mean	8.4	9.6	15.7	13.0
	Minimum	1.5	2.7	6.4	2.2
	σ	1.9	2.3	2.5	3.4
2100	Maximum	12.8	19.4	21.8	23.0
	Mean	8.4	10.5	16.7	13.3
	Minimum	1.4	0.4	4.8	2.5
	σ	1.6	2.2	2.3	3.5

TABLE 11. Diurnal Variation of Maximum, Mean, Minimum, and Standard Deviation of Absolute Humidity in Grams Per Cubic Meter at Jerusalem (31°47'N, 35°13'E, 809m), Israel, for the Period 1973-1981.

Local Time	Variable	Season			
		Winter	Spring	Summer	Fall
0000	Maximum	10.7	12.1	17.3	17.3
	Mean	6.3	7.0	11.4	9.7
	Minimum	0.4	0.5	1.9	1.9
	σ	1.5	2.0	3.5	3.3
0300	Maximum	10.7	15.4	17.3	17.3
	Mean	6.2	6.6	10.7	9.4
	Minimum	0.7	0.4	2.0	2.4
	σ	1.4	2.0	3.5	3.3
0600	Maximum	10.0	12.1	18.3	16.3
	Mean	6.1	6.6	10.8	9.3
	Minimum	0.7	1.4	1.9	1.9
	σ	1.5	1.9	3.4	3.2
0900	Maximum	10.7	12.8	19.4	16.3
	Mean	6.2	6.4	10.0	9.2
	Minimum	0.5	0.5	1.1	1.6
	σ	1.5	2.1	3.4	3.3
1200	Maximum	10.7	17.3	19.4	18.3
	Mean	6.1	6.3	9.7	8.3
	Minimum	0.5	0.5	2.0	1.1
	σ	1.6	2.0	2.7	2.9
1500	Maximum	11.4	13.6	19.4	16.3
	Mean	6.2	6.6	10.7	8.7
	Minimum	0.6	1.1	3.0	1.1
	σ	1.6	2.1	2.5	3.1
1800	Maximum	11.4	14.5	18.3	18.3
	Mean	6.6	7.1	11.1	9.9
	Minimum	0.2	1.1	1.1	1.9
	σ	2.0	2.1	2.7	3.3
2100	Maximum	10.7	14.5	19.4	18.3
	Mean	6.5	7.6	12.5	10.4
	Minimum	0.4	1.1	1.1	0.7
	σ	1.6	2.2	2.8	3.4

TABLE 12. Diurnal Variation of Maximum, Mean, Minimum, and Standard Deviation of Absolute Humidity in Grams Per Cubic Meter at Baghdad (33°15'N, 44°14'E, 34m), Iraq, for the Period 1973-1980.

Local Time	Variable	Season			
		Winter	Spring	Summer	Fall
0000	Maximum	12.1	15.4	15.4	15.4
	Mean	6.6	8.0	8.4	7.6
	Minimum	2.0	0.3	2.4	2.5
	σ	1.7	2.2	1.8	2.1
0300	Maximum	12.1	15.4	15.4	14.5
	Mean	6.4	7.8	8.5	7.4
	Minimum	1.1	0.3	2.4	2.7
	σ	1.7	2.1	1.7	2.0
0600	Maximum	12.1	15.4	16.3	14.5
	Mean	6.2	7.9	8.7	7.2
	Minimum	0.2	3.0	2.0	1.7
	σ	1.8	2.1	1.9	1.9
0900	Maximum	12.1	23.0	19.4	16.3
	Mean	6.8	8.4	9.6	8.0
	Minimum	0.5	2.7	4.2	2.4
	σ	1.7	2.3	2.3	2.4
1200	Maximum	13.6	18.3	19.4	16.3
	Mean	7.1	7.7	8.5	7.7
	Minimum	1.1	2.7	3.9	1.7
	σ	1.9	2.5	2.4	2.4
1500	Maximum	13.6	25.8	18.3	17.3
	Mean	7.0	7.0	7.1	7.0
	Minimum	0.3	1.9	2.7	1.0
	σ	2.1	2.6	2.1	2.4
1800	Maximum	12.8	19.4	19.4	15.4
	Mean	7.0	7.0	7.2	7.8
	Minimum	1.7	2.0	3.0	3.0
	σ	2.0	2.5	2.0	2.3
2100	Maximum	12.8	17.3	21.8	23.0
	Mean	6.9	8.0	8.5	7.8
	Minimum	1.0	1.6	3.2	2.5
	σ	1.9	2.2	2.2	2.2

TABLE 13. Diurnal Variation of Maximum, Mean, Minimum, and Standard Deviation of Absolute Humidity in Grams Per Cubic Meter at Tehran (35°41'N, 51°19'E, 1204m), Iran, for the Period 1973-1980.

Local Time	Variable	Season			
		Winter	Spring	Summer	Fall
0000	Maximum	7.3	11.4	14.5	16.3
	Mean	4.0	5.2	7.0	4.9
	Minimum	0.4	1.0	2.4	0.3
	σ	1.1	2.0	2.2	2.0
0300	Maximum	7.3	15.4	12.8	15.4
	Mean	3.8	5.2	6.8	5.0
	Minimum	0.3	1.0	2.2	0.4
	σ	1.1	1.8	2.0	2.2
0600	Maximum	6.8	15.4	14.5	10.7
	Mean	3.8	5.3	7.0	5.0
	Minimum	0.3	1.3	2.2	1.1
	σ	1.0	1.8	1.9	1.8
0900	Maximum	7.8	18.3	19.4	19.4
	Mean	4.0	5.4	7.2	5.4
	Minimum	1.4	1.6	2.5	1.1
	σ	1.0	1.8	1.9	1.9
1200	Maximum	7.8	18.3	19.4	18.3
	Mean	3.9	5.0	6.9	5.2
	Minimum	0.8	1.5	2.5	1.2
	σ	1.1	1.9	2.0	2.0
1500	Maximum	10.0	17.3	15.4	13.6
	Mean	4.0	4.7	6.6	4.9
	Minimum	1.0	0.9	3.0	0.8
	σ	1.2	1.8	1.7	1.8
1800	Maximum	10.0	17.3	12.8	10.7
	Mean	4.1	4.8	6.5	5.0
	Minimum	0.4	0.9	3.0	1.1
	σ	1.2	1.9	1.9	1.8
2100	Maximum	7.8	15.4	12.1	11.4
	Mean	4.0	5.1	6.8	5.0
	Minimum	0.3	1.0	2.4	0.3
	σ	1.1	2.0	2.0	1.8

TABLE 14. Probability That Visibility is Less Than or Equal to The Given Threshold at Baghdad, Iraq.

Visibility Threshold (miles)*	Season	Local Time 0000	0300	0600	0900	1200	1500	1800	2100
0.23	Winter	.022	.022	.037	.034	.000	.008	.009	.006
	Spring	.005	.000	.003	.002	.002	.002	.003	.004
	Summer	.002	.001	.002	.001	.007	.005	.000	.000
	Fall	.000	.000	.000	.000	.000	.000	.000	.000
0.62	Winter	.032	.033	.052	.067	.015	.027	.018	.014
	Spring	.016	.004	.014	.007	.011	.021	.015	.009
	Summer	.003	.004	.014	.009	.020	.013	.007	.008
	Fall	.004	.002	.002	.006	.002	.003	.007	.005
1	Winter	.038	.041	.066	.101	.039	.041	.033	.024
	Spring	.019	.010	.025	.012	.012	.027	.025	.012
	Summer	.006	.009	.019	.026	.036	.020	.020	.017
	Fall	.004	.002	.005	.010	.005	.005	.011	.005
2	Winter	.048	.053	.081	.247	.104	.086	.070	.040
	Spring	.026	.021	.038	.051	.044	.050	.035	.024
	Summer	.015	.013	.034	.064	.068	.041	.037	.029
	Fall	.013	.006	.009	.068	.026	.013	.024	.008
3	Winter	.072	.067	.099	.323	.163	.107	.094	.059
	Spring	.036	.028	.054	.090	.066	.075	.053	.035
	Summer	.016	.017	.045	.082	.083	.058	.053	.035
	Fall	.021	.008	.018	.113	.054	.023	.033	.015
5	Winter	.162	.208	.264	.709	.401	.228	.230	.149
	Spring	.099	.093	.250	.492	.301	.228	.193	.121
	Summer	.065	.038	.219	.470	.377	.273	.174	.106
	Fall	.073	.040	.186	.625	.357	.151	.207	.099
10	Winter	.998	.998	.998	.997	.992	.998	.995	.998
	Spring	1.000	.997	.998	.997	1.000	1.000	1.000	.998
	Summer	.997	.997	.998	1.000	1.000	1.000	.996	.994
	Fall	1.000	.995	.998	.998	.998	.998	1.000	.998

* 1 mi = 1.61 km

TABLE 15. Probability That Visibility is Less Than or Equal to The Given Threshold at Dhahran, Saudi Arabia.

Visibility Threshold (miles)*	Season	Local Time							
		0000	0300	0600	0900	1200	1500	1800	2100
0.23	Winter	.004	.026	.029	.007	.002	.003	.002	.000
	Spring	.006	.006	.005	.003	.002	.001	.002	.002
	Summer	.002	.001	.003	.000	.005	.003	.000	.000
	Fall	.017	.044	.042	.000	.000	.000	.000	.000
0.62	Winter	.013	.037	.051	.025	.011	.006	.003	.000
	Spring	.010	.014	.012	.011	.013	.008	.007	.002
	Summer	.011	.013	.023	.012	.025	.028	.015	.006
	Fall	.021	.061	.061	.004	.000	.003	.000	.002
1	Winter	.013	.038	.055	.031	.016	.012	.008	.000
	Spring	.013	.017	.015	.014	.022	.016	.007	.002
	Summer	.020	.021	.041	.026	.041	.029	.026	.012
	Fall	.021	.061	.068	.008	.000	.003	.000	.003
2	Winter	.028	.056	.075	.051	.043	.024	.018	.010
	Spring	.017	.021	.036	.037	.045	.037	.026	.009
	Summer	.041	.062	.107	.097	.091	.074	.059	.032
	Fall	.029	.071	.105	.029	.013	.008	.002	.004
3	Winter	.036	.064	.090	.070	.059	.044	.028	.015
	Spring	.025	.028	.043	.064	.066	.056	.037	.024
	Summer	.065	.082	.154	.149	.126	.102	.070	.041
	Fall	.033	.076	.124	.054	.029	.018	.012	.010
5	Winter	.116	.195	.205	.231	.199	.154	.154	.089
	Spring	.084	.090	.174	.258	.228	.208	.190	.073
	Summer	.144	.212	.380	.462	.368	.315	.263	.136
	Fall	.101	.174	.291	.275	.206	.151	.162	.072
10	Winter	1.000	.998	.998	.999	.997	.999	.998	.998
	Spring	.996	1.000	1.000	.999	.998	.999	1.000	.997
	Summer	.998	1.000	.997	1.000	1.000	1.000	1.000	1.000
	Fall	.998	.996	.998	.999	.998	1.000	.998	1.000

* 1 mi = 1.61 km

TABLE 16. Probability That Visibility is Less Than or Equal to The Given Threshold at Jerusalem, Israel.

Visibility Threshold (miles)*	Season	Local Time							
		0000	0300	0600	0900	1200	1500	1800	2100
0.23	Winter	.004	.009	.009	.011	.006	.001	.004	.008
	Spring	.005	.003	.012	.003	.000	.000	.000	.002
	Summer	.002	.008	.011	.000	.000	.000	.000	.001
	Fall	.000	.002	.008	.003	.001	.000	.001	.000
0.62	Winter	.030	.024	.030	.043	.023	.018	.018	.026
	Spring	.012	.016	.039	.017	.006	.004	.001	.005
	Summer	.013	.024	.026	.000	.000	.000	.000	.007
	Fall	.008	.012	.018	.009	.007	.000	.003	.004
1	Winter	.030	.029	.038	.047	.027	.023	.024	.035
	Spring	.012	.016	.039	.019	.006	.005	.001	.006
	Summer	.013	.028	.027	.000	.000	.000	.001	.009
	Fall	.009	.012	.018	.009	.007	.000	.003	.005
2	Winter	.075	.068	.070	.097	.067	.067	.065	.076
	Spring	.034	.043	.085	.053	.022	.019	.018	.026
	Summer	.031	.051	.108	.005	.000	.003	.001	.011
	Fall	.014	.024	.035	.015	.011	.007	.007	.009
3	Winter	.108	.098	.104	.135	.097	.097	.114	.130
	Spring	.060	.076	.124	.086	.052	.041	.042	.075
	Summer	.042	.070	.175	.012	.000	.004	.004	.020
	Fall	.021	.028	.048	.025	.020	.014	.015	.017
5	Winter	.279	.294	.274	.266	.214	.221	.250	.292
	Spring	.230	.246	.256	.222	.148	.162	.174	.229
	Summer	.197	.275	.379	.133	.049	.049	.054	.109
	Fall	.134	.148	.182	.111	.061	.066	.054	.116
10	Winter	.992	.996	.991	.855	.824	.828	.873	.985
	Spring	.994	.994	.970	.826	.783	.810	.856	.964
	Summer	.992	.995	.982	.851	.810	.864	.874	.978
	Fall	.984	.990	.982	.832	.777	.819	.859	.976

* 1 mi = 1.61 km

TABLE 17. Probability That Visibility is Less Than or Equal to The Given Threshold at Tel Aviv, Israel.

Visibility Threshold (miles)*	Season	Local Time 0000	0300	0600	0900	1200	1500	1800	2100
0.23	Winter	.003	.001	.005	.003	.000	.000	.000	.000
	Spring	.001	.005	.013	.005	.000	.000	.000	.000
	Summer	.001	.005	.006	.000	.000	.000	.002	.001
	Fall	.002	.004	.002	.002	.000	.000	.000	.000
0.62	Winter	.005	.003	.009	.006	.001	.003	.003	.001
	Spring	.002	.009	.018	.016	.001	.001	.005	.001
	Summer	.005	.009	.016	.004	.001	.001	.005	.009
	Fall	.002	.004	.004	.006	.001	.000	.000	.000
1	Winter	.006	.005	.010	.010	.005	.005	.006	.004
	Spring	.004	.014	.020	.016	.002	.005	.008	.002
	Summer	.005	.010	.024	.004	.001	.001	.005	.009
	Fall	.002	.005	.004	.009	.001	.000	.000	.000
2	Winter	.014	.014	.015	.035	.028	.023	.018	.010
	Spring	.008	.023	.057	.044	.020	.019	.022	.008
	Summer	.006	.022	.084	.032	.001	.001	.005	.009
	Fall	.005	.008	.006	.019	.005	.006	.002	.002
3	Winter	.019	.020	.023	.053	.041	.033	.031	.014
	Spring	.010	.034	.100	.076	.037	.029	.028	.018
	Summer	.008	.028	.141	.063	.008	.001	.005	.009
	Fall	.005	.010	.006	.032	.009	.009	.004	.004
5	Winter	.175	.213	.227	.377	.270	.210	.240	.164
	Spring	.253	.339	.510	.544	.344	.282	.249	.191
	Summer	.233	.352	.738	.610	.368	.213	.176	.208
	Fall	.094	.143	.190	.339	.178	.115	.125	.077
10	Winter	.994	.990	.988	.967	.874	.829	.901	.982
	Spring	.996	.995	.985	.992	.946	.940	.940	.984
	Summer	.999	.999	.996	.996	.989	.986	.976	.999
	Fall	.996	.998	.990	.973	.907	.848	.926	.982

* 1 mi = 1.61 km

TABLE 18. Probability That Visibility is Less Than or Equal to The Given Threshold at Tehran, Iran.

Visibility Threshold (miles)*	Season	Local Time 0000	0300	0600	0900	1200	1500	1800	2100
0.23	Winter	.007	.008	.009	.005	.002	.002	.004	.006
	Spring	.000	.005	.002	.000	.000	.002	.004	.000
	Summer	.002	.002	.002	.000	.000	.000	.002	.000
	Fall	.000	.000	.000	.000	.000	.004	.002	.004
0.62	Winter	.023	.028	.025	.041	.035	.023	.017	.020
	Spring	.002	.006	.004	.006	.004	.002	.004	.002
	Summer	.002	.002	.002	.002	.000	.002	.002	.002
	Fall	.000	.000	.002	.000	.000	.004	.002	.004
1	Winter	.027	.041	.034	.058	.045	.040	.026	.033
	Spring	.004	.006	.004	.008	.006	.003	.004	.003
	Summer	.002	.002	.002	.003	.000	.002	.002	.002
	Fall	.000	.000	.002	.000	.002	.004	.002	.004
2	Winter	.091	.096	.080	.176	.122	.069	.068	.101
	Spring	.004	.008	.008	.014	.016	.006	.012	.007
	Summer	.002	.005	.002	.008	.004	.003	.006	.003
	Fall	.010	.004	.002	.009	.011	.009	.009	.006
3	Winter	.137	.128	.125	.270	.214	.108	.123	.140
	Spring	.006	.010	.010	.032	.023	.016	.014	.010
	Summer	.002	.008	.006	.028	.013	.005	.012	.008
	Fall	.010	.006	.007	.034	.026	.014	.019	.008
5	Winter	.385	.373	.392	.642	.531	.351	.380	.386
	Spring	.061	.070	.095	.288	.162	.085	.081	.080
	Summer	.034	.037	.109	.329	.140	.053	.045	.056
	Fall	.090	.063	.060	.356	.213	.088	.091	.111
10	Winter	.991	.994	.991	.993	.994	.967	.979	.988
	Spring	.998	.994	.990	.986	.945	.913	.943	.988
	Summer	1.000	1.000	.998	1.000	1.000	.967	.976	.997
	Fall	.995	.996	.998	.996	.987	.955	.974	.996

* 1 mi = 1.61 km

TABLE 19. Cumulative Percent of Cloud Cover Less Than or Equal to The Specified Cloud Amount at Jerusalem.

Time	Season	Cloud Amount (Octas)		
		0	4	7
0000	Winter	41.87	62.95	88.25
	Spring	46.21	68.62	91.34
	Summer	64.62	89.98	99.52
	Fall	57.44	84.21	97.89
0300	Winter	42.66	63.39	88.35
	Spring	48.22	69.77	91.63
	Summer	59.08	87.07	98.69
	Fall	57.27	83.81	97.75
0600	Winter	44.09	63.03	90.30
	Spring	38.04	63.20	88.82
	Summer	49.44	77.53	98.07
	Fall	55.81	82.96	96.83
0900	Winter	24.55	49.66	83.45
	Spring	29.23	54.36	88.21
	Summer	58.46	84.95	100.00
	Fall	41.47	76.00	97.87
1200	Winter	17.97	44.17	82.58
	Spring	23.51	52.47	88.12
	Summer	69.43	92.49	100.00
	Fall	44.96	74.54	97.88
1500	Winter	12.81	38.56	82.70
	Spring	19.77	51.20	89.73
	Summer	64.42	92.88	100.00
	Fall	36.57	72.08	97.38
1800	Winter	14.19	43.95	83.03
	Spring	22.55	55.67	89.43
	Summer	70.88	96.71	100.00
	Fall	41.36	79.39	97.21
2100	Winter	33.10	58.59	85.18
	Spring	38.60	66.62	90.45
	Summer	69.14	94.30	99.74
	Fall	54.39	84.84	98.14

TABLE 20. Cumulative Percent of Cloud Cover Less Than or Equal to The Specified Cloud Amount at Tel Aviv.

Time	Season	Cloud Amount (Octas) 0	4	7
0000	Winter	38.17	64.91	88.17
	Spring	46.95	73.66	94.78
	Summer	61.28	94.49	100.00
	Fall	48.16	83.23	98.60
0300	Winter	38.31	60.28	86.85
	Spring	39.80	69.27	93.45
	Summer	41.16	83.71	99.24
	Fall	41.09	80.78	97.98
0600	Winter	37.52	58.77	87.84
	Spring	23.92	60.18	91.60
	Summer	15.14	72.22	97.62
	Fall	34.85	79.09	97.72
0900	Winter	15.77	50.00	89.36
	Spring	19.47	53.48	90.90
	Summer	19.90	76.20	99.87
	Fall	25.57	74.05	98.23
1200	Winter	15.78	48.77	87.97
	Spring	19.65	54.25	91.89
	Summer	36.63	88.00	100.00
	Fall	25.16	70.14	97.84
1500	Winter	10.86	44.44	88.51
	Spring	19.87	58.73	91.90
	Summer	52.05	95.52	100.00
	Fall	28.95	77.88	98.23
1800	Winter	11.54	50.00	86.79
	Spring	24.18	64.30	92.15
	Summer	55.81	95.83	99.75
	Fall	32.87	79.22	97.86
2100	Winter	31.71	58.95	87.60
	Spring	37.86	74.84	93.21
	Summer	52.68	96.38	100.00
	Fall	47.54	84.36	98.11

TABLE 21. Cumulative Percent of Cloud Cover Less Than or Equal to The Specified Cloud Amount at Dhahran.

Time	Season	Cloud Amount (Octas)		
		0	4	7
0000	Winter	56.36	83.47	95.34
	Spring	59.08	83.56	95.60
	Summer	88.87	97.67	98.56
	Fall	87.04	96.13	98.65
0300	Winter	56.01	82.26	93.84
	Spring	58.29	83.57	95.79
	Summer	88.68	97.74	99.01
	Fall	86.59	96.01	98.72
0600	Winter	44.88	75.26	91.98
	Spring	43.54	75.94	94.93
	Summer	70.13	94.32	98.86
	Fall	71.40	92.72	97.63
0900	Winter	32.25	67.32	90.70
	Spring	39.24	69.69	94.19
	Summer	76.11	95.83	99.58
	Fall	71.41	91.91	99.30
1200	Winter	30.73	68.95	92.83
	Spring	39.78	68.85	92.65
	Summer	82.86	96.86	99.53
	Fall	71.75	93.51	99.35
1500	Winter	30.01	64.04	93.64
	Spring	38.03	68.80	94.59
	Summer	80.53	96.92	99.44
	Fall	70.01	90.23	99.45
1800	Winter	32.05	68.61	93.49
	Spring	34.63	67.06	94.74
	Summer	78.59	95.42	99.18
	Fall	68.56	91.47	99.16
2100	Winter	51.56	81.52	95.68
	Spring	52.69	82.63	96.11
	Summer	84.33	97.68	99.27
	Fall	82.31	96.64	98.98

TABLE 22. Cumulative Percent of Cloud Cover Less Than or Equal to The Specified Cloud Amount at Baghdad.

Time	Season	Cloud Amount (Octas) 0	4	7
0000	Winter	37.48	68.99	86.71
	Spring	40.29	71.04	91.59
	Summer	91.68	99.02	99.51
	Fall	67.98	88.51	95.86
0300	Winter	38.13	66.09	87.03
	Spring	42.25	75.04	93.35
	Summer	92.20	98.55	99.28
	Fall	70.06	89.97	97.41
0600	Winter	37.82	66.39	85.21
	Spring	26.42	67.30	89.15
	Summer	85.85	98.60	99.69
	Fall	60.00	87.86	97.14
0900	Winter	23.28	54.82	84.69
	Spring	29.03	61.83	91.15
	Summer	89.40	97.71	99.86
	Fall	55.56	84.06	98.87
1200	Winter	20.20	56.03	86.59
	Spring	25.71	60.82	90.91
	Summer	89.92	98.18	99.83
	Fall	55.52	83.36	99.12
1500	Winter	13.31	45.39	85.48
	Spring	17.87	53.47	91.14
	Summer	86.70	97.21	99.01
	Fall	50.98	80.07	97.71
1800	Winter	12.74	50.96	86.39
	Spring	16.81	54.08	91.51
	Summer	87.77	98.05	99.82
	Fall	48.61	80.22	97.78
2100	Winter	32.75	65.65	87.38
	Spring	34.55	71.82	92.88
	Summer	90.15	98.62	99.54
	Fall	63.87	87.06	97.31

TABLE 23. Cumulative Percent of Cloud Cover Less Than or Equal to The Specified Cloud Amount at Tehran.

Time	Season	Cloud Amount (Octas)		
		0	4	7
0000	Winter	34.85	60.82	82.92
	Spring	25.19	59.66	92.42
	Summer	49.40	86.20	98.80
	Fall	58.33	86.19	97.62
0300	Winter	35.46	59.66	84.80
	Spring	27.45	64.05	94.12
	Summer	54.72	87.20	99.20
	Fall	58.75	86.88	97.91
0600	Winter	28.86	62.19	85.68
	Spring	18.92	62.16	93.05
	Summer	53.38	88.35	99.25
	Fall	50.34	87.87	98.17
0900	Winter	21.34	56.08	84.30
	Spring	15.19	60.60	92.72
	Summer	55.43	92.39	99.84
	Fall	44.86	82.62	98.23
1200	Winter	16.94	60.00	84.08
	Spring	7.19	59.55	91.58
	Summer	44.44	95.59	100.00
	Fall	33.33	81.94	97.85
1500	Winter	14.24	52.95	83.51
	Spring	3.22	52.89	90.35
	Summer	33.70	94.07	100.00
	Fall	26.69	79.03	97.05
1800	Winter	13.80	54.99	84.29
	Spring	5.12	51.97	89.57
	Summer	36.74	89.39	99.21
	Fall	36.07	78.92	96.25
2100	Winter	32.94	60.43	83.43
	Spring	20.20	59.27	92.82
	Summer	46.58	87.76	99.21
	Fall	56.92	82.65	97.47

TABLE 24. Mean and Standard Deviation of Wind Speed in Meters Per Second at Jerusalem.

Time	Season	Mean	Standard Deviation
0000	Winter	3.35	3.59
	Spring	3.43	3.24
	Summer	4.15	2.23
	Fall	2.69	2.34
0300	Winter	3.25	3.71
	Spring	3.11	3.30
	Summer	3.80	2.30
	Fall	2.40	2.37
0600	Winter	3.21	3.75
	Spring	2.66	3.16
	Summer	3.03	2.39
	Fall	1.95	2.27
0900	Winter	3.31	3.51
	Spring	3.56	2.99
	Summer	3.37	2.07
	Fall	2.46	2.33
1200	Winter	4.66	3.56
	Spring	4.74	3.11
	Summer	4.25	1.93
	Fall	3.52	2.33
1500	Winter	5.30	3.61
	Spring	5.73	3.35
	Summer	6.21	1.94
	Fall	4.48	2.42
1800	Winter	4.64	3.58
	Spring	5.88	3.35
	Summer	7.18	1.92
	Fall	4.90	2.54
2100	Winter	3.55	3.48
	Spring	4.22	3.14
	Summer	5.35	2.29
	Fall	3.45	2.51

TABLE 25. Mean and Standard Deviation of Wind Speed in Meters Per Second at Tel Aviv.

Time	Season	Mean	Standard Deviation
0000	Winter	2.44	2.30
	Spring	1.99	1.60
	Summer	1.69	1.15
	Fall	1.59	1.34
0300	Winter	2.42	2.14
	Spring	2.14	1.92
	Summer	2.02	0.98
	Fall	1.65	1.38
0600	Winter	2.45	2.20
	Spring	2.14	1.92
	Summer	2.03	1.09
	Fall	1.59	1.55
0900	Winter	2.61	2.34
	Spring	2.73	2.41
	Summer	2.68	1.25
	Fall	1.95	1.73
1200	Winter	3.94	2.82
	Spring	4.41	2.64
	Summer	4.27	1.30
	Fall	3.53	1.90
1500	Winter	4.65	2.45
	Spring	5.69	2.20
	Summer	5.32	1.02
	Fall	5.15	1.71
1800	Winter	3.42	2.17
	Spring	4.84	1.89
	Summer	4.66	1.12
	Fall	4.17	1.68
2100	Winter	2.53	1.88
	Spring	2.34	1.73
	Summer	1.98	1.19
	Fall	1.74	1.50

TABLE 26. Mean and Standard Deviation of Wind Speed in Meters Per Second at Dhahran.

Time	Season	Mean	Standard Deviation
0000	Winter	3.05	2.04
	Spring	2.86	2.03
	Summer	2.83	2.36
	Fall	2.17	1.76
0300	Winter	3.20	2.14
	Spring	2.98	2.30
	Summer	3.41	2.41
	Fall	2.49	1.95
0600	Winter	3.44	2.28
	Spring	3.18	2.19
	Summer	3.68	2.41
	Fall	2.73	1.99
0900	Winter	4.25	2.31
	Spring	4.88	2.56
	Summer	5.50	2.84
	Fall	3.78	2.10
1200	Winter	4.87	2.34
	Spring	5.60	2.64
	Summer	6.66	3.14
	Fall	4.41	2.40
1500	Winter	5.28	2.13
	Spring	6.26	2.38
	Summer	7.51	2.62
	Fall	5.41	2.06
1800	Winter	4.06	2.07
	Spring	5.28	2.02
	Summer	5.85	2.03
	Fall	3.96	1.74
2100	Winter	3.09	1.94
	Spring	3.40	2.01
	Summer	2.75	2.40
	Fall	2.40	1.76

TABLE 27. Mean and Standard Deviation of Wind Speed in Meters Per Second at Baghdad.

Time	Season	Mean	Standard Deviation
0000	Winter	2.22	2.52
	Spring	2.64	2.60
	Summer	3.02	1.85
	Fall	1.89	1.65
0300	Winter	2.01	2.32
	Spring	2.53	2.48
	Summer	3.29	2.00
	Fall	1.92	1.71
0600	Winter	1.97	2.23
	Spring	2.56	2.37
	Summer	3.35	2.02
	Fall	1.93	1.65
0900	Winter	2.82	2.47
	Spring	4.38	2.75
	Summer	6.05	2.44
	Fall	3.43	2.26
1200	Winter	3.82	2.74
	Spring	4.78	2.74
	Summer	6.56	2.60
	Fall	4.12	2.37
1500	Winter	4.50	2.76
	Spring	5.28	2.77
	Summer	6.84	2.62
	Fall	4.56	2.49
1800	Winter	3.02	2.50
	Spring	4.75	2.42
	Summer	5.65	2.40
	Fall	2.96	2.32
2100	Winter	2.30	2.39
	Spring	2.76	2.66
	Summer	3.00	1.82
	Fall	2.01	1.61

TABLE 28. Mean and Standard Deviation of Wind Speed in Meters Per Second at Tehran.

Time	Season	Mean	Standard Deviation
0000	Winter	1.24	1.93
	Spring	2.93	2.96
	Summer	2.32	2.16
	Fall	1.68	1.84
0300	Winter	1.22	1.96
	Spring	2.26	2.55
	Summer	1.96	2.09
	Fall	1.71	2.05
0600	Winter	1.04	1.85
	Spring	2.10	2.40
	Summer	1.87	1.93
	Fall	1.54	1.91
0900	Winter	1.29	2.10
	Spring	3.56	3.09
	Summer	3.34	2.23
	Fall	1.93	2.12
1200	Winter	2.69	2.68
	Spring	4.93	3.44
	Summer	4.02	2.28
	Fall	3.13	2.63
1500	Winter	3.17	3.28
	Spring	5.46	3.65
	Summer	3.92	2.54
	Fall	3.74	2.87
1800	Winter	2.33	2.86
	Spring	4.70	3.36
	Summer	3.56	2.60
	Fall	2.25	2.78
2100	Winter	1.44	2.17
	Spring	3.31	2.97
	Summer	2.56	2.50
	Fall	1.79	2.06

REFERENCES

1. Abbas, M. A., and Elnesr, M. K., 1981: The normal pattern of daily insolation and long term transmission characteristics of the atmosphere at Baghdad. Solar Energy, 27, 81-82.

2. Ahmad, I., Al-Hamadani, N., and Ibrahim, K., 1983: Solar radiation maps for Iraq. Solar Energy, 31, 29-44.

3. Ali, F. M., 1953: Predictior of wet periods in Egypt four to six days in advance. J. Meteor., 10, 478-485.

4. Al-Najim, F. A., 1975a: Duststorms in Iraq. Bull. College Sci., University of Baghdad, 16, 437-451.

5. Al-Najim, F. A., 1975b: Frost phenomena in Iraq. Bull. College Sci., University of Baghdad, 16, 453-467.

6. Al-Najim, F. A., 1975c: Thunderstorms in Iraq. Bull. College Sci., University of Baghdad, 16, 469-483.

7. Asculai, E., Doron, E., and Terliuc, B., 1984: Mesoscale flow over complex terrain - a field study in the Lake Kinneret area. Bound-Layer Meteor., 30, 313-331.

8. Ashbel, D., 1938: Great floods in Sinai peninsula. Quart. J. Roy. Meteor. Soc., 64, 635-639.

9. Berry, F. A., Bollay, E., and Beers, N. R., (Eds.), 1973: Handbook of Meteorology. McGraw Hill, New York.

10. Billions, N. S., 1972: Frequencies and Durations of Surface Temperatures in Hot-Dry Climate Category Areas (Cat. 4, AR 70-38). US Army Missile Command Technical Report RR-72-13, 41 pp.

11. Bitan, A., 1974: The wind regime in the north-west section of the Dead Sea. Arch. Meteor. Geophys. Bioklim, B., 22, 313-335.

12. Bitan, A., 1977: The influence of the special shape of the Dead Sea and its environment on the local wind system. Arch. Meteor. Geophys. Bioklim., B., 24, 283-301.

13. Bitan, A., 1981: Lake Kinneret (Sea of Galilee) and its exceptional wind system. Boundary-Layer Meteor., 21, 477-487.

14. Brown, S. C., and Jeffries, W. R., 1985: A New NASA/MSFC Mission Analysis. Global Cloud Cover Data Base. NASA Technical Paper 2448, 16 pp.

15. Christensen, R. E., 1983: Clear Skies at Altitude. ACS/Studies and Analyses, United States Air Force, Rpt No. 22926.

REFERENCES

16. D'Almeida, G. A., and Schutz, L., 1983: Number, mass, and volume distributions of mineral aerosol and soils of the Sahara. J. Cli. Appl. Meteor., 22, 233-243.

17. Daneshyar, M., 1978: Solar radiation statistics for Iran. Solar Energy, 21, 345-349.

18. Dayan, U., and Abramski, R., 1983: Heavy rain in the Middle East related to unusual jet stream properties. Bull. Amer. Meteor. Soc., 64, 1138-1140.

19. De Jong, B., 1973: Net Radiation Received by a Horizontal Surface at the Earth. Delft University Press, Rotterdam.

20. Dodd, A. V., 1969: Areal and Temporal Occurrence of High Dew Points and Associated Temperatures. US Army Natick Laboratories Technical Report 70-4-ES, 218 pp. (Available Defense Technical Information Center. No. AD 707919.)

21. Dregne, H. E., Editor, 1970: Arid Lands in Transition. Washington, Amer. Assoc. Advancement Sci., 524 pp.

22. Durward, J., 1930: Squalls at Amman, Transjordan. Quart. J. Roy. Meteor. Soc., 56, 175-178.

23. Environmental Science Services Administration, 1966: World Weather Records, Vol. 2, Europe. Washington, US Department of Commerce.

24. Environmental Science Services Administration, 1967a: World Weather Records, Vol. 4, Asia. Washington, US Department of Commerce.

25. Environmental Science Services Administration, 1967b: World Weather Records, Vol. 5, Africa. Washington, US Department of Commerce.

26. Gabriel, K. R., Avichai, Y., and Steinberg, R., 1967: A statistical investigation of persistence in the Israeli artificial rainfall stimulation experiment. J. Appl. Meteor., 6, 323-325.

27. Gabriel, K. R., and Petrondas, D., 1984: Reply. J. Cli. Appl. Meteor., 23, 853-854.

28. Gillette, D. A., Blifford, I. H., and Fryrear, D. W., 1974: The influence of wind velocity on the size distributions of aerosols generated by the wind erosion of soils. J. Geophys. Res., 79, 4068-4075.

29. Gillette, D., and Goodwin, P. A., 1974: Microscale transport of sand-sized soil aggregates eroded by wind. J. Geophys. Res., 79, 4080-4084.

REFERENCES

30. Godske, C. L., Bergeron, T., Bjerknes, J., and Bundgaard, R. C., 1957: Dynamic Meteorology and Weather Forecasting. Published jointly by the American Meteorological Society, Boston, and the Carnegie Institution, Washington, see p. 11 and p. 637.

31. Griffiths, J. F., 1959: The variability of annual rainfall in East Africa. Bull. Amer. Meteor. Soc., 40, 361-362.

32. Hameed, S., 1984: Fourier analysis of Nile flood levels. Geophys. Res. Lett., 11, 843-845.

33. Hanna, S. R., 1969: The formation of longitudinal sand dunes by large helical eddies in the atmosphere. J. Appl. Meteor., 8, 874-883.

34. Hassan, F. A., 1981: Historical Nile floods and their implications for climatic change. Science, 212, 1142-1145.

35. Hinds, B. D., and Hoidale, G. B., 1975: Boundary Layer Dust Occurrence, II, Atmospheric Dust over the Middle East, Near East, and North Africa. Atmospheric Science Laboratory Research and Development Technical Report ECOM-DR-75-4. (Available NTIS number AD A022637.)

36. Holst, G. C., Milham, M. E., and Anderson, D. H., 1982: Optical Communication Through Dust Storms. Chemical Systems Laboratory Report AR CSL-TR-81061. Distribution limited to US Government agencies.

37. Howe, G. H., Reed, L. J., Ball, J. T., Fisher, G. E., and Lassow, G. B, 1968: Classification of World Desert Areas. US Army Natick Laboratories Technical Report 69-38-ES, 104 pp.

38. Huschke, R. E., Ed., 1959: Glossary of Meteorology. American Meteorological Society, Boston, see pp. 227-228.

39. Katsnelson, J., and Kotz, S., 1957: On the upper limits of some measures of variability. Arch. Meteor. Geophys. Bioklim., B, 8, 103-107.

40. Khalili, A., 1973: Precipitation patterns of the central Elburz. Arch. Meteor. Geophys, Bioclim., Ser. B, 21, 215-232.

41. Khalili, A., 1976: Precipitation climatology of the Tehran area. Meteor. Mag., 105, 293-306.

42. Krown, L., 1966: An approach to forecasting seasonal rainfall in Israel. J. Appl. Meteor., 5, 590-594.

43. Kudish, A. I., Wolf, D., and Machlav, Y., 1983: Solar radiation data for Beer Sheva, Israel. Solar Energy, 30, 33-37.

REFERENCES

44. Kushelevsky, A., Shani, G., and Haccoun, A., 1983: Effect of meteorologic conditions on total suspended particulate (TSP) levels and elemental concentration of aerosols in a semi-arid zone (Beer-Sheva, Israel). Tellus, 35B, 55-64.

45. Kutiel, H., 1982: Spatial coherence of the monthly rainfall in Israel. Arch. Meteor. Geophys. Bioclim., Ser. B, 31, 353-367.

46. Kutiel, H., and Sharon, D., 1980: Diurnal variation of rainfall in Israel. Arch. Meteor. Geophys. Bioclim., Ser. A, 29, 387-395.

47. Kutiel, H., and Sharon, D., 1981: Diurnal variation in the spatial structure of rainfall in the northern Negev Desert Israel. Arch. Meteor. Geophys. Bioclim., Ser. B, 29, 239-243.

48. Levin, Z., and Lindberg, J. D., 1979: Size distribution, chemical composition, and optical properties of urban and desert aerosol in Israel. J. Geophys. Res., 84, 6941-6950.

49. Löf, G. O. G, Duffie, J. A., and Smith, C. O., 1966: World distribution of solar radiation. Solar Energy, 10, 27-37.

50. Newell, R. E., Condon, E. P., and Reichle, H. G., 1981: Measurements of CO and CH_4 in the troposphere over Saudi Arabia, India, and the Arabian Sea during the 1979 International Summer Monsoon Experiment (MONEX). J. Geophys. Res., 86, 9833-9838.

51. Normand, C. W. B., 1919: Meteorological conditions affecting aviation in Mesopotamia. Quart. J. Roy. Meteor. Soc., 45, 368-379.

52. Otterman, J., and Tucker, C. J., 1985: Satellite measurements of surface albedo and temperatures in semi-desert. J. Cli. Appl. Meteor., 24, 228-235.

53. Otterman, J., and Sharon, D., 1979: Day/night partitioning of rain in an arid region. J. Rech. Atmos., 13, 11-20.

54. Patterson, E. M., and Gillette, D. A., 1977a: Measurements of visibility vs mass-concentration for airborne soil particles. Atmos. Environ., 11, 193-196.

55. Patterson, E. M., and Gillette, D. A., 1977b: Commonalities in measured size distributions for aerosols having a soil-derived component. J. Geophys. Res., 82, 2074-2082.

56. Petterssen, S., 1958: Introduction to Meteorology. McGraw-Hill, New York, see pp. 104-106.

57. Riehl, H., El-Bakry, M., and Meitín, J., 1979: Nile river discharge. Mon. Wea. Rev., 107, 1546-1553.

REFERENCES

58. Riehl, H., and Meitin, J., 1979: Discharge of the Nile river: A barometer of short-period climate variation. Science, 206, 1178-1179.

59. Riordan, P., 1974: Weather Extremes around the World. US Army Engineer Topographic Laboratories Report ETL-TR-74-5, see page 50. (Available NTIS, No. AD-A-000 802.)

60. Rudloff, W., 1981: World-Climates. Wissenschaftliche Verlagsgesellschaft, Stuttgart, pp. 230-245.

61. Schumann, T. E. W., and Mostert, J. S., 1949: On the variability and reliability of precipitation. Bull. Amer. Meteor. Soc., 30. 110-115.

62. Schütz, L., and Jaenicke, R., 1974: Particle number and mass distributions above 10^{-4} cm radius in sand and aerosol of the Sahara desert. J. Appl. Meteor., 13, 863-870.

63. Segal, M., Pielke, R. A., and Mahrer, Y., 1983: On climatic changes due to a deliberate flooding of the Qattara Depression (Egypt). Climatic Change, 5. 73-83.

64. Sfeir, A. A., 1981: Solar radiation in Lebanon. Solar Energy, 26, 497-502.

65. Sharon, D., 1978: Rainfall fields in Israel and Jordan and the effect of cloud seeding on them. J. Appl. Meteor., 17, 40-48.

66. Sharon, D., 1979: Correlation analysis of the Jordan Valley rainfall field. Mon. Wea. Rev., 107, 1042-1047.

67. Shehadeh, N. A., 1984: Discomfort in Sharjah. Meteor. Mag., 113, 114-120.

68. Sherr, P. E., Glasen, A. H., Barnes, J. C., and Willand, J. H., 1968: World-Wide Cloud Cover Distribution for Use in Computer Simulations. Marshall Space Flight Center Technical Report NASA CR-61226.

69. Soliman, K. H., 1953: Rainfall over Egypt. Quart. J. Roy. Meteor. Soc., 79, 389-397.

70. Sowelim, M. A., 1983: Characteristics of storm deposited dust at Cairo. Atmos. Environ., 17, 145-149.

71. Stewart, D. A., and Essenwanger, O. M., 1982: A survey of fog and related optical propagation characteristics. Rev. Geophys. Space Phy., 20, 481-495.

72. Striem, H. L., 1979: Some aspects of the relation between monthly temperatures and rainfall and its use in evaluating earlier climates in the Middle East. Climatic Change, 2, 69-74.

REFERENCES

73. Striem, H. L., 1981: Climatic fluctuations in Israel viewed through rainfall regimes. Arch. Meteor. Geophys. Bioclim., Ser. B, 29, 357-364.

74. Striem, H. L., and Rosenan, N., 1973: Rainspells, as a climatological parameter, used in the analysis of rainfall in Jerusalem. Arch. Meteor. Geophys. Bioclim., Ser. B, 21, 25-42.

75. Takahashi, K., and Arakawa, H., 1981: Climates of Southern and Western Asia. World Survey of Climatology, Volume 9, H. E. Landsberg, Editor-In-Chief, Amsterdam, Elsevier, pp. 183-255.

76. Tomasi, C., 1984: Vertical distribution features of atmospheric water vapor in the Mediterranean, Red Sea, and Indian Ocean. J. Geophys. Res., 89, No. D2, 2563-2566.

77. Turner, A. E., 1978: Discomfort in Bahrain. Weather, 33, 334-338.

78. Wernstedt, F. L., 1972: World Climatic Data. Lemont, Pennsylvania, Climatic Data Press.

79. Winstanley, D., 1973: Recent rainfall trends in Africa, the Middle East, and India. Nature, 243, 464-465.

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